DORIC

Trend-Cal™ 466

DIGITAL CALIBRATOR

EMERSON

DORIC SCIENTIFIC DIVISION
EMERSON ELECTRIC CO.
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OWNER'S MANUAL

WARRANTY

Doric Scientific hereby warrants each instrument of its manufacture as follows:

1. At the time of delivery of each instrument to the original purchaser, Doric Scientific UNCONDITIONALLY WARRANTS that it shall be free from defects in parts, materials and workmanship; and

2. Commencing with the date of shipment of each instrument to the original purchaser, Doric Scientific UNCONDITIONALLY WARRANTS that each unit shall remain free from defect in parts, materials and workmanship for a period of 1 year.

In the event any instrument fails to meet the terms of this warranty, Doric Scientific agrees to provide corrective action. Refer to the Owner's manual for the proper procedure.

The warranties herein shall not obligate Doric Scientific in any manner whatsoever with respect to, and shall not be applicable to, any defects which after an inspection by Doric Scientific are not to Doric Scientific's reasonable satisfaction demonstrably the result of defective parts, materials or workmanship. We are not liable for consequential damages.

CERTIFICATION

Doric Scientific certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when shipped from the factory. Doric Scientific further certifies that its calibration measurements are traceable to NBS.

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SECTION 1

GENERAL DESCRIPTION

1.1 GENERAL DESCRIPTION

The Model 466 digital calibrator is a precision instrument for the indication (input) or calibration (output) of thermocouple, current, or DC voltage devices. The calibrator is available in two configurations. Version T accommodates NBS type J, K, T, R, S, and B thermocouples only. Version L offers a combination of NBS type J, K, T, E thermocouples; −10 to +100 mV linear DC voltage; and 0-20 mA current.

The calibrator is housed in a rugged steel chassis with a carrying handle for portability. The calibrator can operate from AC line power or integral battery pack for portable DC operation. The front panel features a bold 0.8" LED display for easy readability, and quick disconnect terminals for easy connections to the calibrator.

1.2 PHYSICAL DESCRIPTION

All printed circuit cards are housed in modular, die-cast aluminum cases within a steel transit/bench package.

1.3 UNPACKING AND INSPECTION

The instrument leaves the factory in perfect condition and is shipped in a special carton to protect it from shipping damage. However, shipping damage can occur at times. Upon receipt, inspect the instrument for any possible transit damage and determine that all items ordered have been received.

Carefully review the operation section of the manual before using the instrument. Contact our Customer Service department immediately if any problems are observed.

1.3.1 Repacking, Returning the Instrument

The original shipping carton should be saved in case the instrument must be returned for repair or modification. When returning an instrument for any reason, the following information (attached to the unit) is required: model number, serial number, your name, billing address, shipping address, phone number, and a description of the malfunction or modification. This information will enable our Customer Service Department to expedite the return of your instrument. Instruments being returned to the factory shall be shipped freight prepaid.

Instruments being returned for warranty service must also refer to the original purchase date on packing lists and purchase orders. Instruments without this information will be processed as a non-warranty repair at current service rates.

If the original shipping carton has been discarded, repack the instrument as follows:

a. Select a strong cardboard box of sufficient size to allow an inch of packing material around all sides of the unit.
b. Ensure that all printed circuit boards are secured and front and rear panels firmly in place.
c. Wrap the instrument in plastic or strong paper. Place it centrally in the shipping container, and pack polyfoam, bubblepack, or rubberized hair around all sides of the instrument.
d. Tape the carton flaps securely and label the container "FRAGILE, DELICATE INSTRUMENT". Ship the instrument, freight prepaid(do not ship by U.S. Mail).

1.4 SPECIFICATIONS

1.4.1 Input*

Input Impedance

Thermocouples: >10 Megohms
Voltage: 1000 Megohms
Current: 5 ohms

* Warm-up time to rated accuracy is 1 hour.

RANGE DESIGNATOR	TYPE OF INPUT	RANGE	ACCURACY (all ±) includes max. linearization error
J (NBS)	Iron-Constantan Thermocouple	-328 to +1712°F -200 to +933°C	0.6°F 0.5°C
K (NBS)	Chromel-Alumel Thermocouple	-208 to +2552°F -133 to +1400°C	1.2° < 0° < 0.8° 0.8° < 0° < 0.5°
T (NBS)	Copper-Constantan Thermocouple	-328 to +752°F -200 to +400°C	0.5°F 0.5°C
R (NBS)†	Platinum-Platinum 13% Rhodium Thermocouple	+32 to +3252°F 0 to +1788°C	3° < 350°F < 1.5° 2° < 200°C < 1° 0.6° above 800°C
S (NBS)†	Platinum-Platinum 10% Rhodium Thermocouple	+32 to +3252°F 0 to +1788°C	2° < 600°F < 1.5° 2° < 315°C < 1° 0.5° above 800°C
B (NBS)†	Plat. 30% Rhod/ Plat. 6% Rhod Thermocouple	912 to +3392°F 489 to +1866°C	2.5° 1°
E (NBS)*	Chromel-Constantan Thermocouple	-328°F to +1952°F -200°C to +1066°C	0.7° 0.4°
mV *	Linear Voltage	-10 to +100 mV	0.01% of reading ±2 counts
mA *	Current Transmitter	0 to 20 mA	0.01% of reading ±2 counts

Stability with Temperature

Zero: 0.5 μV/°C
Span: 0.005% rdg/°C
Reference Junction: 0.025° per degree 10-40°C (50 to 104°F) base metal types;
0.05° per degree for noble metals.

Repeatability

± 1 digits (J, K, T, E, mV and mA ranges)
± 2 digits: T range below −200°F
± 2 digits (R, S, and B ranges)

Noise Rejection

NMR: 56 dB @ 50 Hz, 60 dB @ 58 Hz or higher
CMR: 110 dB @ 50 Hz, 120 dB 58-62 Hz (250 ohm unbalance)

† Version ; only

* Version L only

Open TC or Break Detection

30 nanoamp, negative dc

Overload Protection

Input fuse and diode clamping protection

Input Connection

Thermocouple: compensated mini-connector
Current, Voltage: 5-way miniature binding posts

1.4.2 Output

Output Range

Thermocouple/Voltage: -10 mV to +100 mV
Current: 0 to 20 mA into 0-150 ohms

Output Impedance

Thermocouple/Voltage : 1 ohm
Open T/C or Break Detection: 30 nanoamps, negative DC

Output Connection

Thermocouple: compensated mini-connector
Current, Voltage: 5-way miniature binding posts

1.4.3 Controls/Indicators

Self-Test Pushbutton Switch

Provides fixed reference source to check calibrator for each measurement function.

Function Select Pushbutton Switches

Version T: selects J, K, T, R, S, or B
Version L: selects J, K, T, E, mA, or mV

Input/Output Select Pushbutton Switches

Selects input or output mode for themocouple, current, and voltage modes.

Battery ON/OFF Switch

Connects battery power to the instrument for portable usage.

Low Battery Indicator

Red LED indicator illuminates to warn of low battery charge.

Instrument Display

Seven Segment LED display, 0.8" (20.3 mm) digit height.

Fahrenheit/Celsius Select Pushbutton Switch

Selects F° or C° readout for thermocouple ranges.

Fine Output Adjust

A 4-turn potentiometer and switch that turns the calibrator circuitry ON (output mode) and provides a fine adjustment of calibrator output to within 0.1°, 10 μV, or 1 μA depending on range used.

Coarse Output Adjust

A 10-turn potentiometer provides a coarse adjustment of the calibrator output to within the range of the FINE control.

1.4.4 Power

AC Power Requirements

Jumper selectable 100-125 VAC or 190-250 VAC, 48-400 Hz.
Typical power consumption: 1.5 watts (5 watts when charging battery).

Battery

10 volts, rechargeable, sealed module, 2-4 hours continuous operation per charge typical. Recharge time is 14 hours maximum and good for 500 cycles. Modular replacement.

1.4.5 Environmental/Physical Specifications

Operating Range: 0° to 50° C.

Storage Range: -40° to 60° C.

Relative Humidity: 0 to 90%, non-condensing (to 40° C).

Size: 6.13" W x 10.51" H x 9.45" D (156 mm x 267 mm x 240 mm).

Weight: 11.5 lbs (5.175 kg).

Warranty: 12 months.

SECTION 2

OPERATION

2.1 GENERAL OPERATION

See Figure 2-1 for locations of all controls, connectors, and indicators described in the following paragraphs.

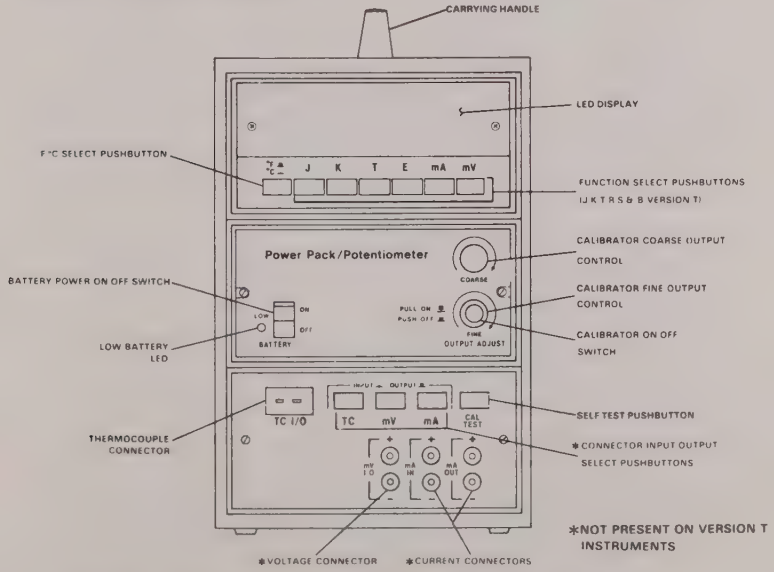


FIGURE 2-1. FRONT VIEW, CALIBRATOR (VERSION L SHOWN)

2.1.1 Applying Power to the Instrument

The instrument can be used on direct line power or as a portable unit using the instrument's internal, rechargeable battery pack source.

A rocker-type switch is located on the front of the instrument for turning the battery pack power source on/off. See Figure 2-1. This switch should be in the OFF position for line power or battery recharge operation. With the battery switch in the ON position, the unit can be removed from line power and used as a portable instrument for 2 to 4 hours (typical) of continuous operation.

The instrument may be operated on line power with the battery switch in the ON position. However, this will put unnecessary drain on the battery, limiting the life expectancy of the battery pack.

2.1.1.1 Selecting Power Voltage

The instrument is configured to operate from a 100, 120, 230, or 240 VAC 48-400 Hz power source as specified on the order.

To reconfigure the instrument for the desired power voltage, the indicator printed circuit board (pcb) assemblies are removed from the chassis and the main board pcb modified for the appropriate voltage:

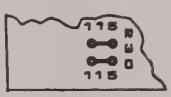
a. Remove instrument rear cover (six screws).
b. Remove indicator input wires (black/white) from input terminal strip.
c. Remove cable connector from indicator plug P2.
d. Remove display plexiglas (two screws).
e. Remove two screws securing display board to front of chassis.
f. Slide entire assembly out from front of chassis.
g. Per Figure 2-2 below, cut etch(es) and install appropriate jumper(s) according to the main board pcb version being modified.
h. Re-assembly is reverse of removal.

NOTE

Observe proper polarity when re-installing indicator input wires (+V/white, −V/black) and cable connector (paint stripe visible when installed).

CORNER OF PCB ADJACENT TO POWER PLUG:
("X" DENOTES CUT ETCH)

VERSION 1 PCB:



115 VAC
OPERATION

230 VAC
OPERATION

VERSION 2 PCB:

100 VAC
OPERATION

120 VAC
OPERATION

230 VAC
OPERATION

240 VAC
OPERATION

FIGURE 2-2. POWER VOLTAGE CONFIGURATION

2.1.2 Low Battery LED

The Low Battery LED indicator is located on the front panel, directly left of the battery power switch. The LED illuminates when the battery charge is low and the instrument is on battery power (battery switch ON). The LED is always off when the instrument is on line power (battery being charged).

2.1.3 Signal Connections

A miniature, quick-disconnect, thermocouple connector is used for all thermocouple connections. The connector has a special built-in reference junction compensation to allow types J, K, T, E, R, S, or B thermocouples to be connected to the instrument.

The instrument is provided with a set of 6 ft. (1.83 meters) 24 AWG thermocouple cables terminated on one end with the appropriate mating connector. It is important to note that an Omega Type SMP (or equivalent) mating connector for the thermocouple type being used should be utilized to ensure the most accurate readings. Extra sets of thermocouple cables are available as an accessory item:

Model number 466A-TCWT supplies an extra set of four thermocouple cables with mating mini-connector for types J, K, T, R, S, and B inputs (one cable is used for types R, S, and B thermocouples).

Model number 466A-TCWL supplies an extra set of four thermocouple cables with mating mini-connector for types J, K, T, and E inputs.

Voltage and Current ranges on Version L instruments utilize 5-way binding posts for connection of signal input/output. Connections to the posts may be made in several ways. If the signal wire terminates in a standard banana plug, it may be inserted directly into the end of the binding post. By unscrewing the binding post cap, signal wires up to 14 AWG may be terminated by wrapping around the post or by inserting the wire through the hole provided in the post. The cap should be tightened against the wire to make a secure connection.

2.1.4 Range/Function Selection

Two instrument models are available to meet the user's specific needs. Version T units accommodate types J, K, T, R, S, and B thermocouples. Version L units accommodate types J, K, T, and E thermocouples; −10 to +100 mV linear DC voltage; and 0-20 mA current.

Pushbutton switches directly below the display are used to select one of six ranges for display. The six rightmost switches are interlocked so that only one switch at a time can be pushed. The leftmost pushbutton switch is used to select °F or °C readout for thermocouple ranges. Push this switch in for °C readout, or push out for °F readout.

On Version L units only, input/output mode is selectable by pushbutton switches on the bottom front portion of the instrument. Each of the three general functions, thermocouple (TC), millivolts (mV), and milliamps (mA) are provided with a pushbutton switch which is pushed in for input or pushed out for output.

2.1.5 Self Test

A momentary contact pushbutton switch provides a quick check of instrument calibration. Immediately after the instrument is received or after calibration, push the CAL TEST switch and record the display reading (allow time for a stable reading) for all ranges. Refer to the recorded figures whenever a check of instrument calibration is performed. If the reading differs by more than two counts, the instrument is due for calibration.

2.2 OPERATION GUIDE

The instruments are available for input (indication) and output (calibration) measurements for all types of thermocouple, voltage, and current devices. In addition, the Version L instrument has the unique ability of calibrating temperature transmitters by outputting a thermocouple signal source and simultaneously displaying the transmitter's 0-20 mA output.

The various operating modes of the instrument are detailed below.

INPUT MODE (Calibrator Output Control OFF)

Measurement Type	Operation Sequence
THERMOCOUPLE INPUT (all instruments)	1. Apply power to instrument.
	2. Ensure calibrator output control is OFF (inner knob of FINE control pushed IN).
	3. Press TC input/output switch IN for input mode (Version L instruments only).
	4. Observing correct polarity, connect thermocouple input to TC mini-connector.
	5. Select J, K, T, E, R, S, or B function.
	6. Select °F or °C display.
	7. Note temperature reading on display.
VOLTAGE INPUT (Version L only)	1. Apply power to instrument
	2. Ensure calibrator output control is OFF (inner knob of FINE control pushed IN).
	3. Press mV input/output switch IN for input mode.
	4. Observing correct polarity, connect input to binding posts labeled "mV I/O".
	5. Select mV function by pressing "mV" switch below display.
	6. Note voltage reading on display.
CURRENT INPUT (Version L only)	1. Apply power to instrument.
	2. Ensure calibrator output control is OFF (inner knob of FINE control pushed IN).
	3. Press mA input/output switch IN for input mode
	4. Observing correct polarity, connect input to binding posts labeled "mA IN".
	5. Select mA function by pressing "mA" switch below display.
	6. Note current reading on display.

OUTPUT MODE (Calibrator Output Control ON)

Measurement Type	Operation Sequence
THERMOCOUPLE SOURCE (all instruments)	1. Observing correct polarity, connect appropriate thermocouple wire to TC miniconnector on front panel
	2. Select J, K, T, E, R, S, or B function.
	3. Select °F or °C display.
	4. Press TC input/output switch OUT for output mode (Version L instruments only).
	5. Apply power to instrument.
	6. Turn calibrator output ON by pulling out inner knob of FINE control.
	7. Observing display, adjust COARSE/FINE controls to desired output setting.
	8. Proceed with calibration.
ISOLATED THERMOCOUPLE TRANSMITTER (Version L only)	1. Observing proper polarity, connect appropriate thermocouple wire from transmitter input to TC mini-connector.
	2. Select J, K, T, or E function.
	3. Select °F or °C display.
	4. Press TC input/output switch OUT for output mode.
	5. Observing proper polarity, connect transmitter output to mA input binding posts.
	6. Apply power to instrument.
	7. Turn calibrator output ON by pulling out inner knob of FINE control.
	8. Observing display, adjust COARSE FINE controls to desired output setting
	9. Instrument is now outputting calibrated TC signal to transmitter
	10. Press mA function switch below display to read transmitter output.
	11. Proceed with transmitter calibration.

CURRENT SOURCE (Version L only)	1. Observing proper polarity, connect instrument to be calibrated to mA output binding posts.
	2. Press mA function switch below display.
	3. Press mA input/output switch OUT for output mode.
	4. Apply power to instrument.
	5. Turn calibrator output ON by pulling out inner knob of FINE control.
	6. Observing display, adjust COARSE/FINE controls for desired setting.
	7. Proceed with calibration.

SECTION 3

CALIBRATION

3.1 CALIBRATION, GENERAL

This section describes calibration of the digital calibrator.

3.1.1 Equipment Required

NOTE

*Items marked with asterisk are required for Version L instruments only.

a. millivolt source: −010.00 to +100.00 mV, ±1 μV accuracy

b. stable ice bath: 32.0 °F ±.05 °F

c. 5½ digit DVM: 2 μV resolution, ±2 μV accuracy *

d. milliamp source: 0 to 20.000 mA, ±1 μA accuracy *

e. wire-wound precision resistor: 50 ohms, .01% *

f. appropriate TC wire and mini-connector (Omega Type SMP, or equivalent), and copper hookup wire for each thermocouple range to be calibrated (see Figure 3-1).

3.1.2 Preliminary Setup

The basic calibration setup is shown in Figure 3-1. For thermocouple ranges, it is important to use the appropriate mini-connector for connecting the calibration probe to the digital calibrator. The mini-connector is labeled with the appropriate thermocouple type and is color coded as follows:

Type J - Black
Type K - Yellow
Type T - Blue
Type R - Green
Type S - Green
Type B - White
Type E - Purple

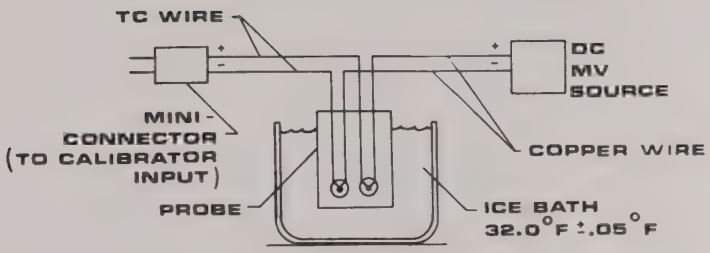


FIGURE 3-1. BASIC CALIBRATION SETUP

Assemble the basic calibration setup shown in Figure 3-1 as follows:

a. Connect the appropriate thermocouple mini-connector and thermocouple wire to the TC input connector on the front panel of the instrument being calibrated; press the corresponding display select pushbutton.

b. Form junctions between each thermocouple wire (Hi and Lo) with a length of copper wire. Electrically isolate these junctions and insert both junctions in the ice bath.

c. Connect the copper wires from the ice bath to the millivolt source, observing proper polarity.

d. Apply power to the millivolt source and the instrument being calibrated. Allow the instrument to stabilize for about one hour before proceeding.

3.2 CALIBRATION, VERSION T INSTRUMENTS

The following procedure is used to calibrate Version T instruments. The basic setup must be assembled per 3.1.2 above with power applied to the instrument for approximately one hour before proceeding. Note that all calibration is performed in °F for optimum calibration accuracy. Refer to Figure 3-2 for locations of pot adjustments.

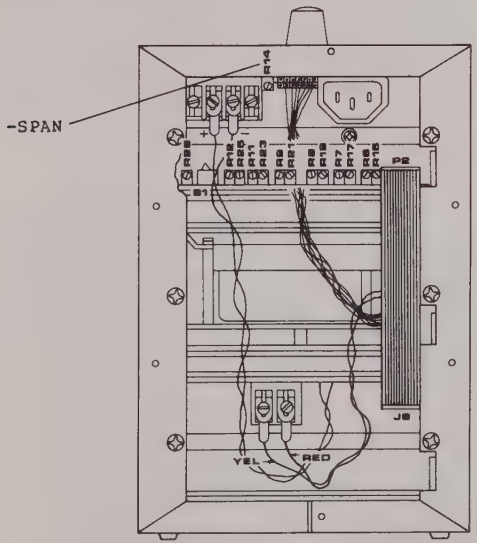


FIGURE 3-2. REAR VIEW OF CALIBRATOR, POT ADJUSTMENTS

NOTE

Refer to Table 3-1 and Figure 3-2 for calibration values and pot locations respectively. It is recommended that calibration proceed in sequence as shown in Table 3-1, reading top to bottom.

a. Adjust the output of the millivolt source to 0.000 mV.

b. Refering to the appropriate ZERO row of Table 3-1, adjust the ZERO adjust pot for a display reading as shown in the display reading column of the table.

c. Refering to Table 3-1, adjust the output of the millivolt source to the appropriate +full scale value.

d. Refering to the appropriate + FS row of Table 3-1, adjust the + FS adjust pot for a display reading as shown in the display reading column of the table.

e. The – full scale (– FS) calibration is performed after calibrating + full scale of the J range: adjust the output of the millivolt source to – 7.791 mV.

TABLE 3-1

TYPE	INPUT		ADJUST POT	FOR A DISPLAY READING OF:
J	ZERO	0.000 mV	R6	32.0°F
	+ FS	42.567 mV	R15	1390.0°F
	– FS	– 7.791 mV	-span (R14)	– 320.0°F
K	ZERO	0.000 mV	R7	32.0°F
	+ FS	54.484 mV	R17	2500.0°F
T	ZERO	0.000 mV	R8	32.0°F
	+ FS	20.801 mV	R19	750.0°F
R	ZERO	0.000 mV	R9	32.5°F
	+ FS	21.006 mV	R21	3200.0°F
S	ZERO	0.000 mV	R11	32.5°F
	+ FS	18.612 mV	R23	3200.0°F
B	ZERO	0.000 mV	R12	32.0°F
	+ FS	13.124 mV	R25	3200.0°F

f. Adjust pot R14 on the indicator for a display reading of −320.0 °F.

g. Remove the thermocouple from the instrument. Connect new type thermocouple to instrument and press the corresponding display select pushbutton. Repeat steps 3.2.a through 3.2.g for the remaining ranges, inputting the appropriate voltage and adjusting the corresponding pot for the desired display reading for each type thermocouple as outlined in Table 3-1 below.

I. After all ranges have been calibrated, record the CAL TEST readings for each range by selecting the range and holding in the CAL TEST pushbutton on the front panel. Refer to these recorded readings when checking the CAL TEST reading of a range. CAL TEST readings should be within ±0.2 °F of the recorded readings.

CALIBRATION COMPLETED

3.3 CALIBRATION, VERSION L INSTRUMENTS

The following procedure is used to calibrate Version L instruments. The basic setup must be assembled per 3.1.2 above with power applied to the instrument for approximately one hour before proceeding. Note that calibration of thermocouple ranges is performed in °F for optimum calibration accuracy. Refer to Figure 3-3 for locations of pot adjustments.

NOTE

Refer to Table 3-2 and Figure 3-3 for calibration values and pot locations respectively. It is recommended that calibration proceed in sequence as shown in Table 3-2, reading top to bottom.

a. Connect the appropriate thermocouple to the instrument's front panel TC input connector per 3.1.2. If linear inputs are being calibrated, connect the millivolt or milliamp source to the appropriate front panel binding posts, observing proper polarity.

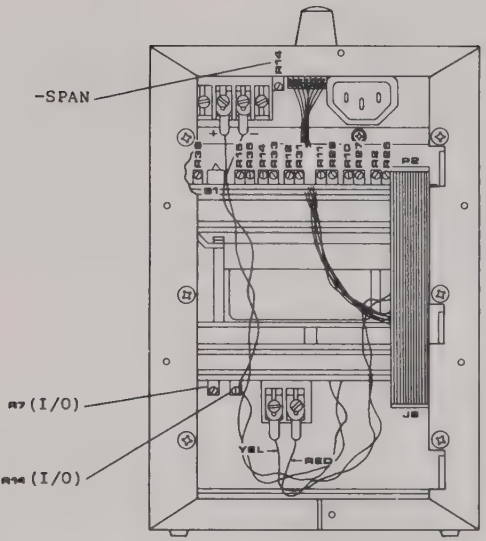


FIGURE 3-3. REAR VIEW OF CALIBRATOR, POT ADJUSTMENTS

b. Push IN the appropriate input/output select pushbutton on the bottom portion of the front panel for the range being calibrated (i.e. if calibrating type J TC, push TC input/output select pushbutton IN).

c. Press the appropriate display select pushbutton below the display.

d. Refering to Table 3-2, adjust the output of the source to the appropriate zero input value.

e. Refering to the appropriate ZERO row of Table 3-2, adjust the ZERO adjust pot for a display reading as shown in the display column of the table.

f. Refering to Table 3-2, adjust the output of the source to the appropriate +full scale value.

g. Referring to the appropriate +FS row of Table 3-2, adjust the +FS adjust pot for a display reading as shown in the display reading column of the table.

h. The −full scale (−FS) calibration is performed after calibrating +full scale of the J range: adjust the output of the millivolt source to −7.791 mV.

i. Adjust pot R14 on the indicator for a display reading of −320.0 °F.

j. Repeat steps 3.3.a through 3.3.g for each type range as outlined in Table 3-2 below.

TABLE 3-2

TYPE	INPUT		ADJUST POT	FOR A DISPLAY READING OF:
J	ZERO	0.000 mV	R2	32.0°F
	+FS	42.567 mV	R25	1390.0°F
	−FS	−7.791 mV	-span (R14)	−320.0°F
K	ZERO	0.000 mV	R10	32.0°F
	+FS	54.845 mV	R27	2500.0°F
T	ZERO	0.000 mV	R11	32.0°F
	+FS	20.801 mV	R29	750.0°F
E	ZERO	0.000 mV	R12	32.0°F
	+FS	75.024 mV	R31	1800.0°F
mV IN	ZERO	0.000 mV	R15	−000.00 mV
	+FS	100.00 mV	R35	100.00 mV
mA IN	ZERO	0.000 mA	R14	−00.000 mA
	+FS	20.000 mA	R33	20.000 mA

3.3.2 Calibrating Linear Output (mA Output).

a. Connect the 50 ohm precision resistor (.01% wire-wound) across the mA output binding posts.

b. Connect the DVM across the resistor. Set DVM to 100 mV range.

c. Press the "mA" display select pushbutton below the display.

d. Push OUT the mA input/output select pushbutton on the lower portion of the instrument front panel.

e. Turn ON the instrument calibrator output (pull out inner knob of FINE adjust pot).

f. Adjust the instrument's output adjust controls for a display reading on the instrument of −00.000 mA.

g. Adjust R7 on the I/O board for a DVM reading of 000.00 mV ±0.01 mV.

h. Set voltmeter range to 1 volt.

i. Adjust the instrument's output adjust controls for a display reading on the instrument of 20.000 mA.

j. Adjust R14 on the I/O board for a DVM reading of 1.0000 V ±0.1 mV.

k. Remove resistor from mA output binding posts.

3.3.3 CAL TEST READINGS

a. After all ranges have been calibrated, record the CAL TEST readings for each range by selecting the range and holding in the CAL TEST pushbutton on the front panel. Refer to these recorded readings when checking the CAL TEST reading of a range. CAL TEST readings should be within ±0.2 °F for thermocouple ranges, ±0.02 mV for the millivolt range, and ±0.002 mA for the milliamp range.

CALIBRATION COMPLETED

SECTION 4

THEORY OF OPERATION

4.1 MAIN BOARD

4.1.1 Dual Slope A/D Conversion

Refer to the simplified schematic of analog circuits (Figure 4-1) and diagram of dual slope technique (Figure 4-2). Before each conversion (T_0), analog switches S2 and S3 are closed. The autozero and zero cross detector circuits close the loop around the integrator, establishing a starting point for the integration.

During T_1, S2 and S3 are opened, S1 is closed, and the integrator is allowed to ramp up (down for $+E_{IN}$). After a known number of clock pulses, S1 is opened, S2 is closed, and a short pause occurs to settle capacitor charging.

During T_3, S5 is connected (S4 if $+E_{IN}$) and the integrator ramps back toward zero at a constant rate. The amount of time (counts) required to return to zero is proportional to the input voltage. After zero crossing, the system returns to autozero.

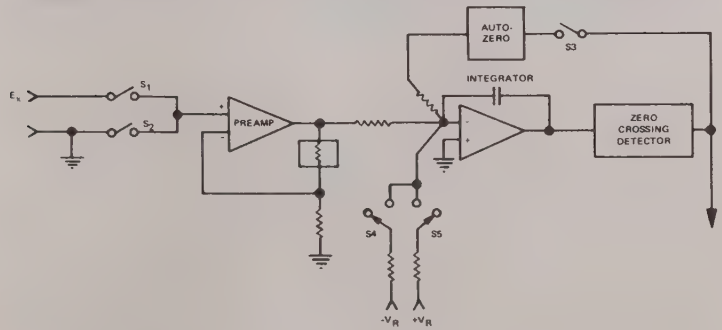


FIGURE 4-1. SIMPLIFIED SCHEMATIC, ANALOG CIRCUITS

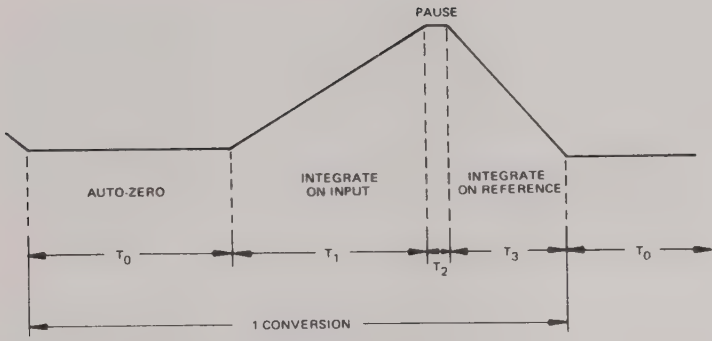


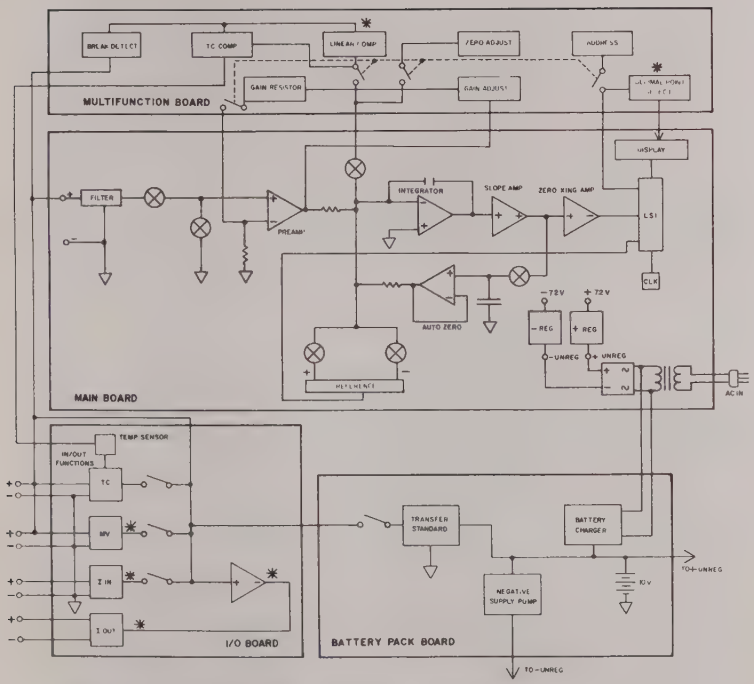
FIGURE 4-2. DUAL SLOPE TECHNIQUE

4.1.2 Power Supply and Regulator

Refer to schematic 400-6190. AC power is connected at P1, filtered for RFI, and connected to power transformer T1. The rectified secondary voltage provides + 11 VDC on C4 and C5 (LED display power) and − 11 VDC on C6. The two amplifiers of Z8 drive pass transistors Q1 and Q2. If excessive current is drawn through Q1 and Q2, resistors R3 and R9 limit the peak currents, thus protecting the supply. Potentiometer R13 adjusts the power supply voltage.

4.1.3 Display and Driver

The seven segments of the common-cathode LED displays are driven by seven emitter-follower Darlington transistors (Q9 through Q12). Current through each segment is limited by resistor network Z11. Hex driver Z10 provides digit (common-cathode) drive of which the multiplex rate is controlled by LSI chip Z9.



* ITEMS MARKED WITH ASTERISK ARE CIRCUIT FUNCTIONS FOUND ON VERSION L INSTRUMENTS ONLY

BLOCK DIAGRAM-DIGITAL CALIBRATOR

4.1.4 Digital Logic

Z9 is a PMOS digital integrated circuit which operates from the regulated +7.2 and −7.2 voltages. Pins 15 through 20 are digit strobes for driving digit selection driver Z10. Pins 23 through 29 provide segment data for generating the display. Pin 6 of Z9, a clock input, receives the 400 kHz clock, generated by C18, R38, R39, and Z7 pins 11-15. Pin 33 is a power-on reset input used in conjunction with R41 and C21. Pin 33 clears internal logic and prepares the dynamic logic for the first conversion. Pin 35 is the "start convert" line and delays conversion by a time constant generated by Q7, R40, and C20. Pins 37 through 40 provide the A/D conversion switching logic (see Figure 4-1) which controls the FET switches. Pins 7 through 9 of Z9 are used to select the appropriate linearization table within the chip for the range being used.

4.2 MULTIFUNCTION BOARD

The Multifunction board provides switching of various ranges. Ranges are selected by dual DPDT pushbutton switches (S2-S7) which are interlocked so that only one switch at a time can be pressed. Selection of a particular range addresses the LSI chip for the appropriate linearization via diodes CR1-CR11. Particular circuit requirements of each range are switched in-circuit as each range is selected.

Each thermocouple range places an individual zero offset and preamp gain (span) network into the preamp/integrator circuits on the main board in addition to the required reference junction compensation.

Selecting any linear function automatically switches out the reference junction circuit and introduces a fixed negative offset (approx. −320 counts) in the offset node (integrator input) so that zero input results in zero counts.

Decimal point placement is automatic as each range is switched. Darlington transistors Q1, Q2, and Q3 apply LED I+ to the appropriate decimal point segment as follows:

Thermocouple:	0000.0	Q1	ON
millivolts:	000.00	Q2	ON
milliamps:	00.000	Q3	ON

Degrees F or degrees C readout is selected by switch S8 which controls the F/C line to the LSI chip (pin 5) on the main board. Degrees F is selected by default by the internal pulldown in the chip. Degrees C is selected by switching +7.2 volts to the

F/C line via resistor R19, and diode CR13. Usage of any linear function requires that the degrees F mode be selected. This is accomplished by turning on Q4 when any linear function is selected. The result is that CR13 is reversed biased which causes the F/C line to be pulled low by the chip regardless of the position of S8.

4.3 POWER PACK/CALIBRATOR BOARD

Refer to schematic 407-6110. Capacitors C1, C2, and C3, and rectifier CR1 provide voltage doubling of the raw AC signal from the secondary side of the main board transformer. Z3 is a protected constant voltage regulator. The output of Z3 is trimmed to the nominal charge voltage of 11.75V at the anode of CR4. Resistors R1, R2, and R3 adjust the output voltage of Z3, and diode CR4 protects Z3 from battery current when not in the charging mode. Switch SW1 disconnects the battery from loads in the OFF position (open). Resistors R4 and R5, and op-amp Z1 pins 12, 13, and 14 put a trickle load on the battery to sense low voltage. If the unit is on and the battery voltage drops below about 10 volts, LED CR8 is turned on via current limiting resistor R7. The raw battery voltage is fed back to the + unregulated node of the main board by CR2. This voltage is in parallel with any unregulated voltage that may be supplied by the transformer on the main board.

Z2, C4, and R6 form a free running oscillator and driver for transistors Q1 and Q2 at about 5 kHz. Q1 and Q2 provide a "charge pump" effect to generate the lower current − unregulated supply through CR5, CR6, CR7, C5, C6, and C7. This voltage is decoupled from the main board with CR3.

Two pots are used to control the calibrator output. Coarse adjustment is provided by 10-turn wirewound pot R10. Pot R10 is biased correctly by R8, R9, and R11. Resistor R13 injects offset current to R10 via pot R12, thus providing a fine adjustment. Pot R12 is a 4-turn carbon composition unit ganged with a two-pole push-pull switch (S2). With S2 pulled out, S2 pins 5 and 6 are open, disconnecting the calibrator output from the instrument. S2 pins 7 and 8 effectively short the calibrator, preventing interactive ground currents from flowing. Op-amp Z1 pins 10, 9, and 8 provide high impedance referencing of the pot circuit to ground. Op-amp Z1 pins 2, 3, and 1 provide a buffered output and drive the output divider R14 and R15. Op-amp Z1 pins 5, 6, and 7, and resistors R16, R17, and R18 generate an opposing current to the output divider and prevent offset from occuring in return wires to the instrument.

4.4 I/O BOARD

The I/O board provides the input/output interface to the indicator section of the instrument and the transfer standard output from the Power Pack/Calibrator section of the instrument.

Input protection is provided by a fast blow fuse and diode clamping for each type input (TC, mA, mV). The fuse limits current to 500 mA. The diode clamps limit voltage to no more than .7 V in either polarity.

Reference Junction (RJ) compensation is provided by transdiode Q1, pot R1, and resistors R2 and R3. Transdiode Q1 is mounted on the TC mini-connector for accurate tracking of the termination temperature. Pot R1 sets the bias current of Q1 via divider network R2 and R3. RJ compensation is used to eliminate the inaccuracies that can result from thermocouple effects of the termination due to temperature differences of dissimilar metals. The termination is made to look thermally stable despite ambient temperature by injection of a voltage at the LO side of the input. This voltage is the result of current flow through Q1 which varies proportionally (within limits) with the temperature to which it is exposed.

Switches S4 provides a self check feature by disconnecting the input/output and reading a fixed voltage set by voltage dividers R20 and R23 on the HI side, and R21 and R22 on the LO side. The LO side divider is used to provide a fixed voltage to the LO side in order to negate the effect of the variable voltage source provided by the RJ compensation circuit.

The I/O board used in Version L instruments (TC and linear functions) is provided with extra circuitry to accommodate the various functions. Refer to schematic 400-6820-xx.

The three input types, TC, mA and mV are multiplexed to a common output to the indicator by multiplexer Z1. Selection of which input to pass is determined by the binary value of the AB inputs of Z1 pins 9 and 10. These inputs are addressed by the appropriate switch selection on the Multifunction board.

Because of the usage of multiplexer Z1, injection on the break detect current is located on the I/O board before the multiplexer (On TC only instruments, break detect current is provided on the Multifunction board.) Resistors R26 (TC), R27 (mA), and R28 (mV) provide break detect current for the three functions.

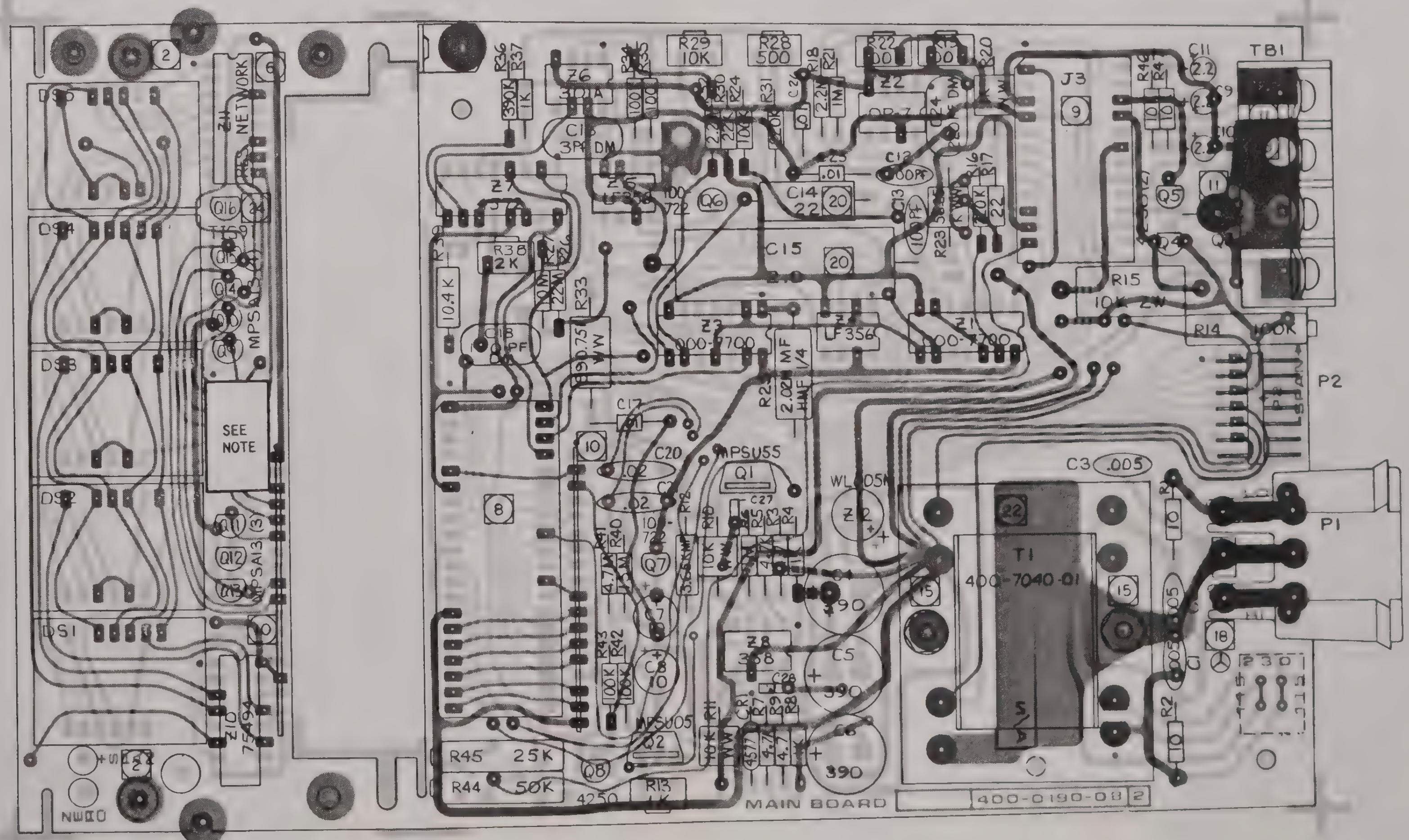
Op-amps Z2 and Z3, transistors Q2 and Q3, and associated components comprise the current source. The circuit is essentially two op-amps and transistor drivers in cascade. The first op-amp/driver stage (Z2 and Q2) is non-inverting. As the

transfer standard input becomes more positive, Z2 turns on NPN transistor Q2 proportionally which causes current flow through R12 when + mA output is connected to – mA output through a suitable impedance (0-200 ohms). The second op-amp/driver stage is inverting. As the transfer standard goes more positive, Z3 is driven more negative which turns on PNP transistor Q3 proportionally, driving – mA output more negative. Thus, a current loop is established, with one stage driving positive, and the other stage driving negative. Diode CR7 and resistor R11 provide controlled bias to Q2 in the event Z2 is driven negative. Diode CR11 and R17 provide controlled bias for Q3 in the event Z3 is driven positive. Pot R14 adjusts the gain of the first stage which determines the current span.

SECTION 5

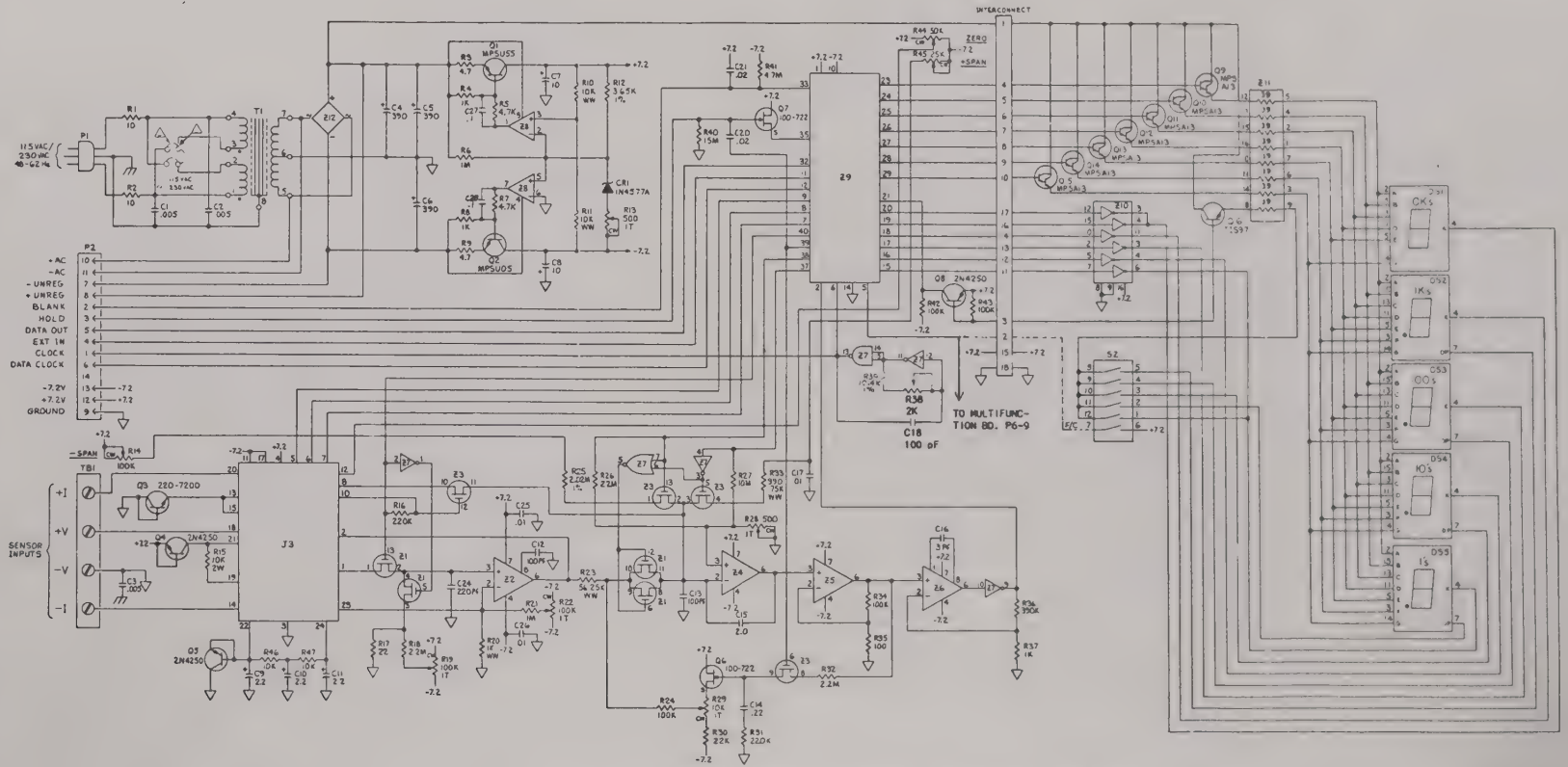
DRAWINGS

TITLE	DRWNG. NO.	PAGE
Assembly, MAIN BOARD	400-4860-00/ 400-4861-00	5-1
Schematic, MAIN BOARD	400-6860-00/ 400-6861-00	5-2
Parts List, MAIN BOARD		6-1
Assembly, MULTIFUNCTION BD (TC)	400-4460-00	5-3
Schematic, MULTIFUNCTION BD (TC)	400-6460-00	5-4
Parts List, MULTIFUNCTION BD (TC)		6-4
Assembly, MULTIFUNCTION BD (TC/LIN)	400-4461-00	5-5
Schematic, MULTIFUNCTION BD (TC/LIN)	400-6461-00	5-6
Parts List, MULTIFUNCTION BD (TC/LIN)		6-3
Assembly, POWER PACK/POT	407-4110-00	5-7
Schematic, POWER PACK/POT	407-6110-00	5-8
Parts List, POWER PACK/POT		6-5
Assembly, I/O BOARD (TC)	400-4821-00	5-9
Schematic, I/O BOARD (TC)	400-6821-00	5-10
Parts List, I/O BOARD (TC)		6-7
Assembly, I/O BOARD (TC/LIN)	400-4820-00	5-11
Schematic, I/O BOARD (TC/LIN)	400-6820-00	5-12
Parts List, I/O BOARD (TC/LIN)		6-6
OUTLINE DRAWING	400-8090-00	5-13
ASSEMBLY/INTERCONNECTIONS	400-4870-00/ 400-4871-00	5-14



NOTE: THIS COMPONENT IS A 14-PIN DIP SOCKET (J9) FOR ASSY. 400-4860-00.
THIS COMPONENT IS A 6-POLE DIP SWITCH (S2) FOR ASSY. 400-4861-00.

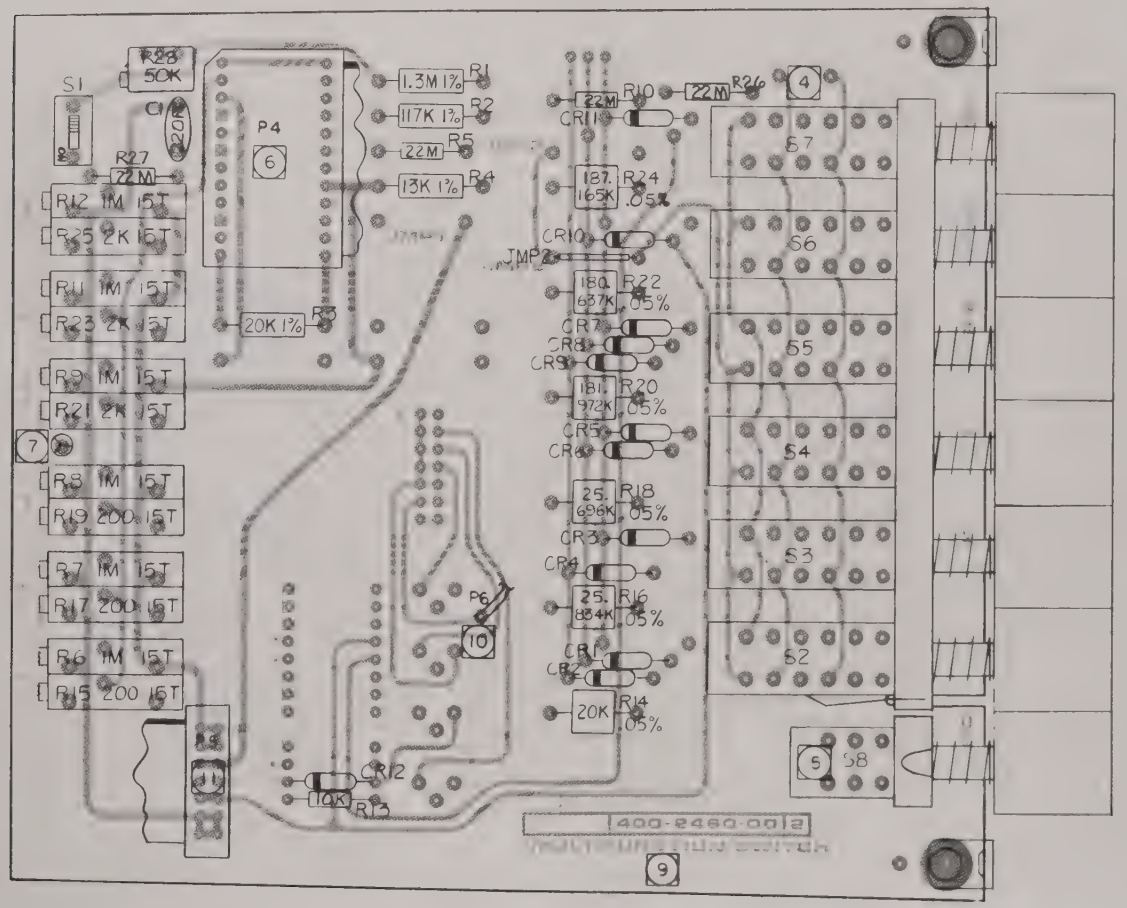
Assembly
MAIN BOARD
400-4860-00/
400-4861-00



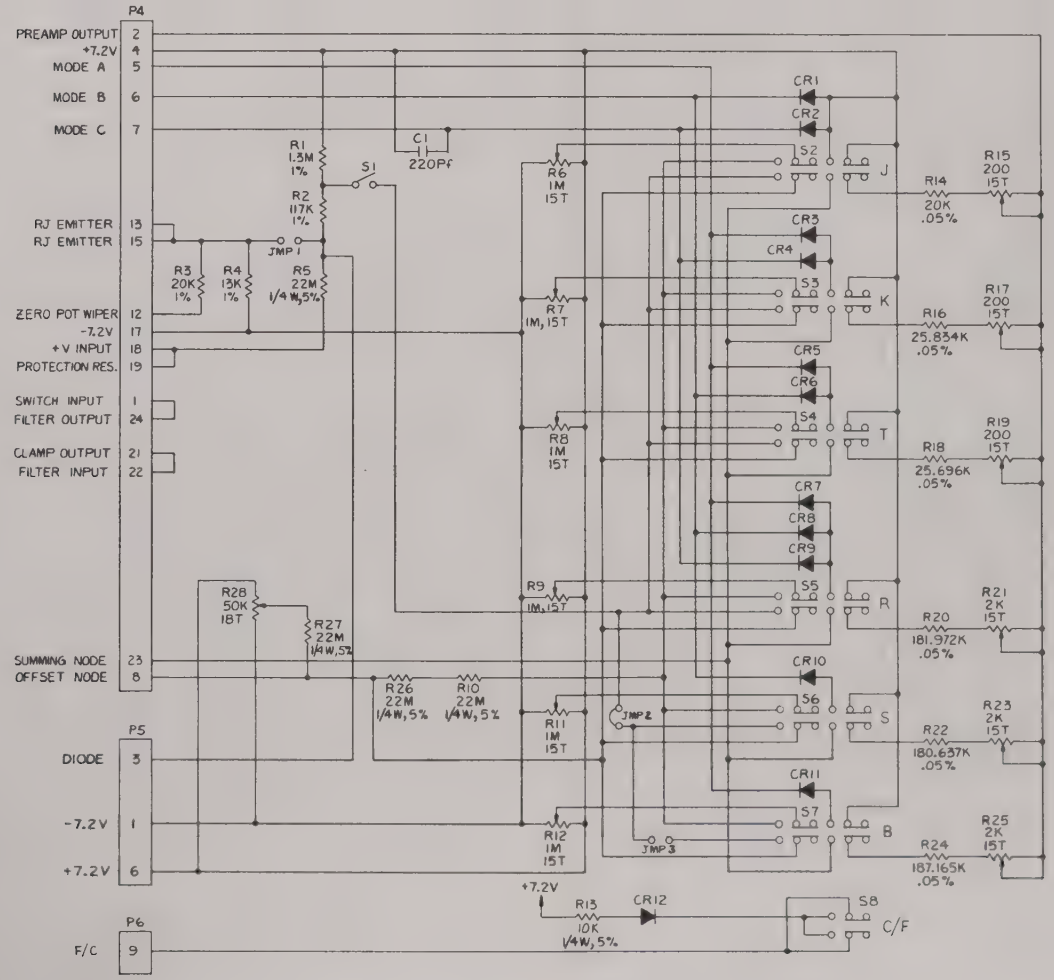
NOTES: DASHED LINE DENOTES INTERCONNECT USED FOR ASSEMBLY 400-4860-00 ONLY.

A 14-PIN DIP SOCKET (J9) IS USED IN PLACE OF S2 FOR ASSEMBLY 400-4860-00 ONLY.

Schematic
MAIN BOARD
400-6860-00/400-6861-00

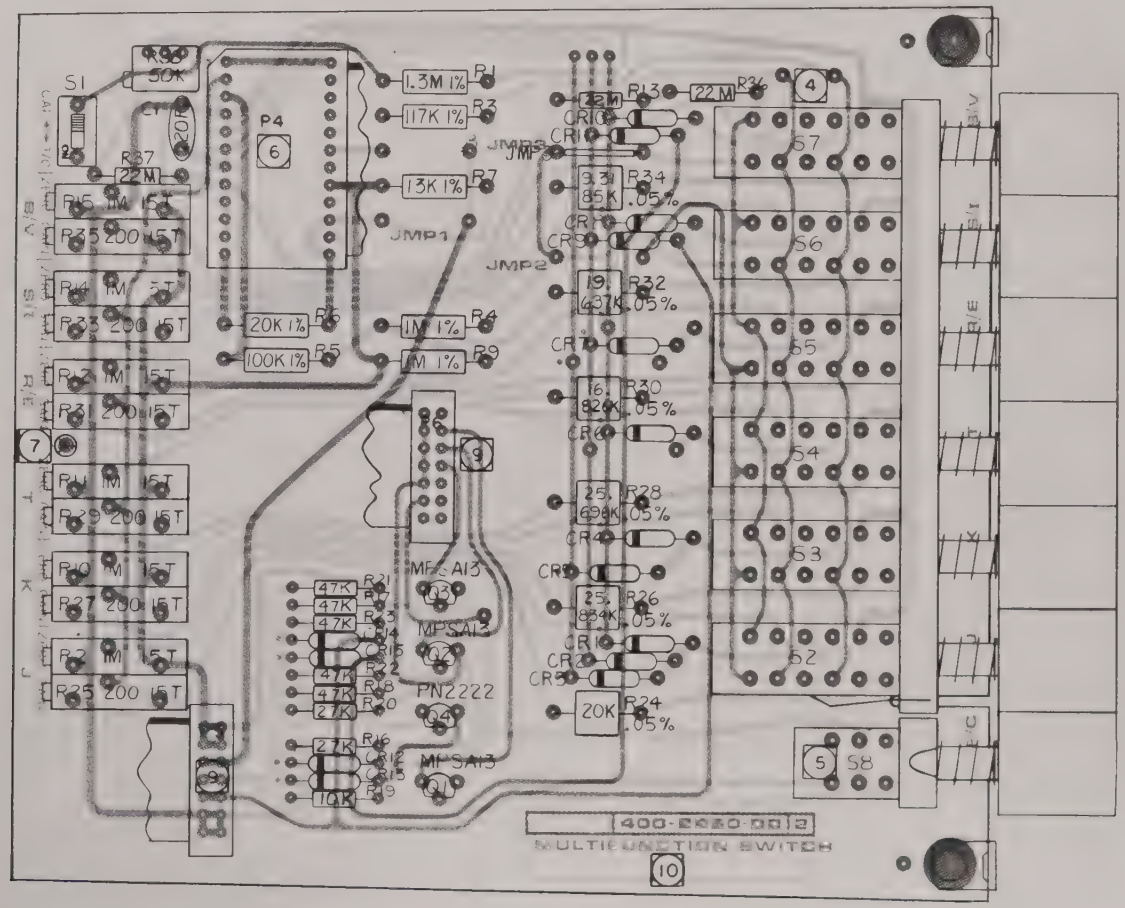


Assembly
MULTIFUNCTION BOARD (TC)
400-4460-00

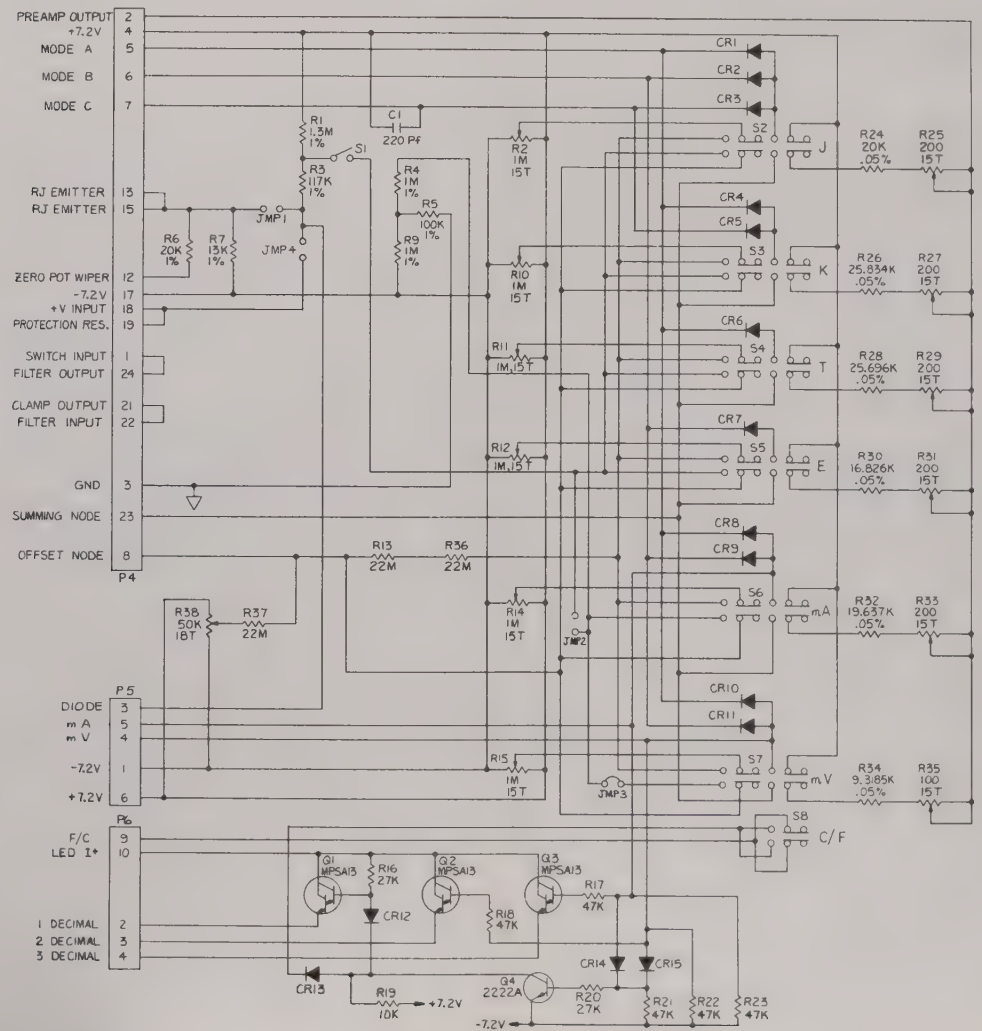


INTERLOCKING SWITCHES S2 THROUGH S7 ARE SHOWN IN NON-SELECTED POSITION

Schematic
MULTIFUNCTION BOARD (TC)
400-6460-00

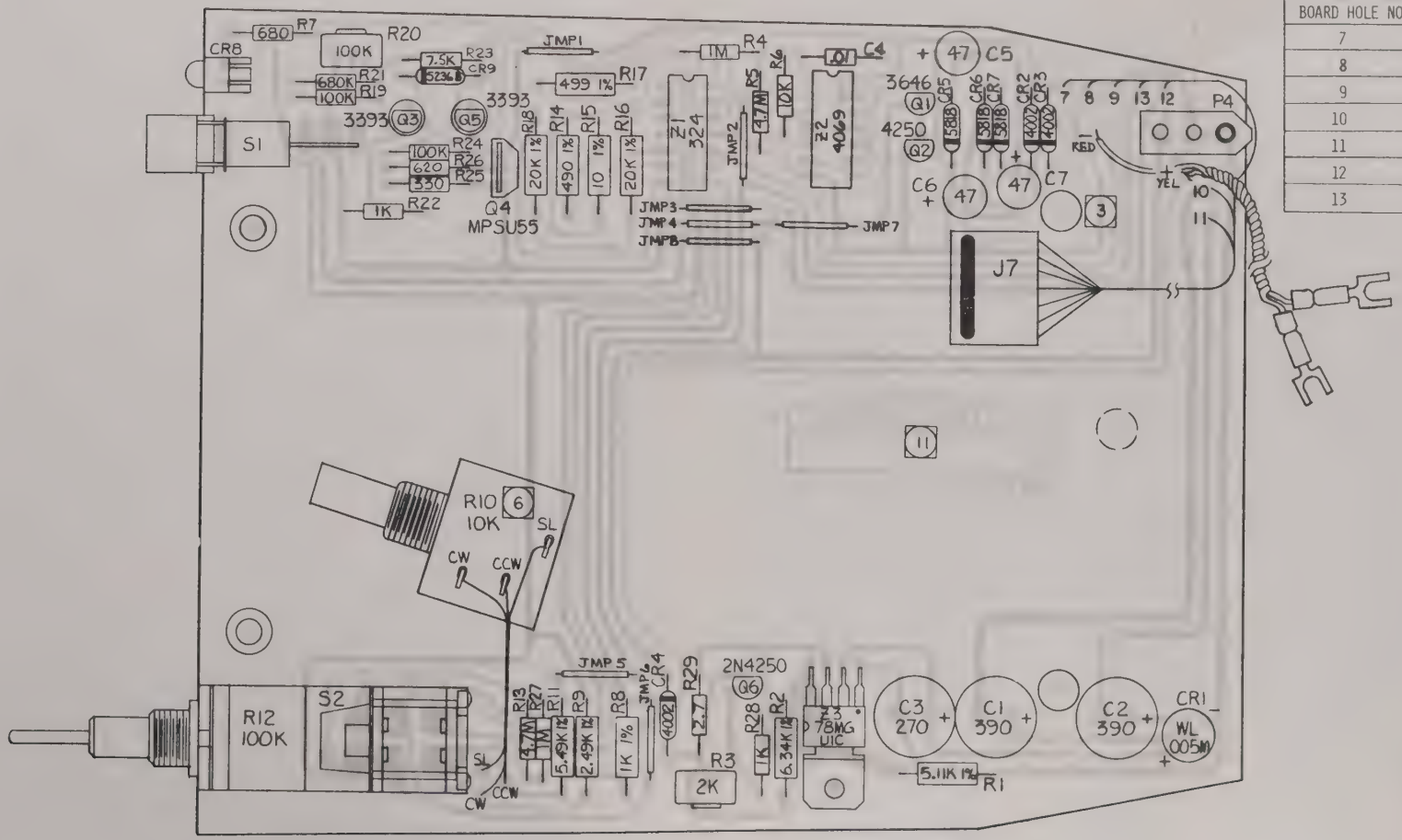


Assembly
MULTIFUNCTION BOARD (TC/LIN)
400-4461-00



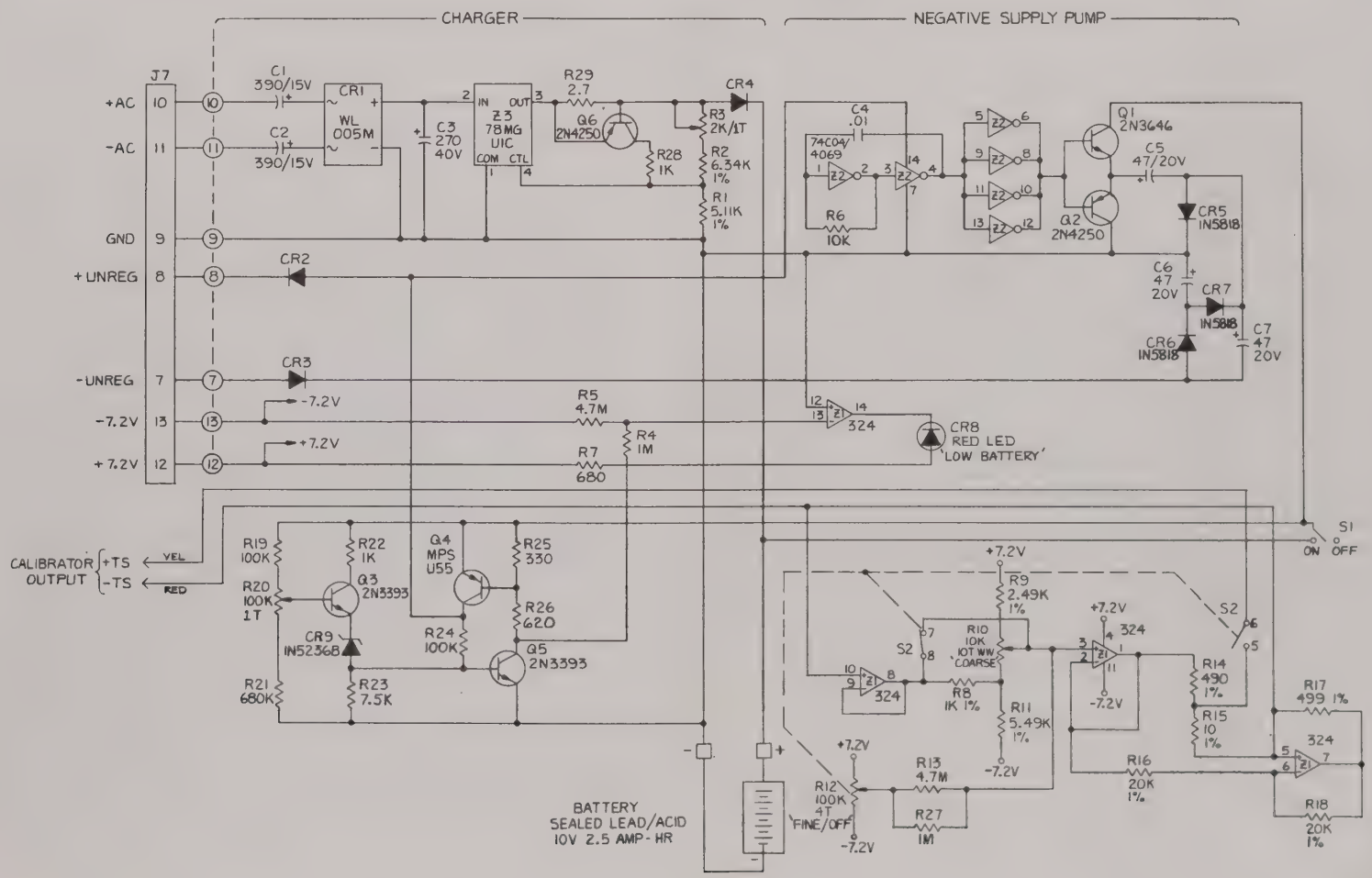
INTERLOCKING SWITCHES S2 THROUGH S7 ARE SHOWN IN NON-SELECTED POSITION

Schematic
MULTIFUNCTION BOARD (TC/LIN)
400-6461-00

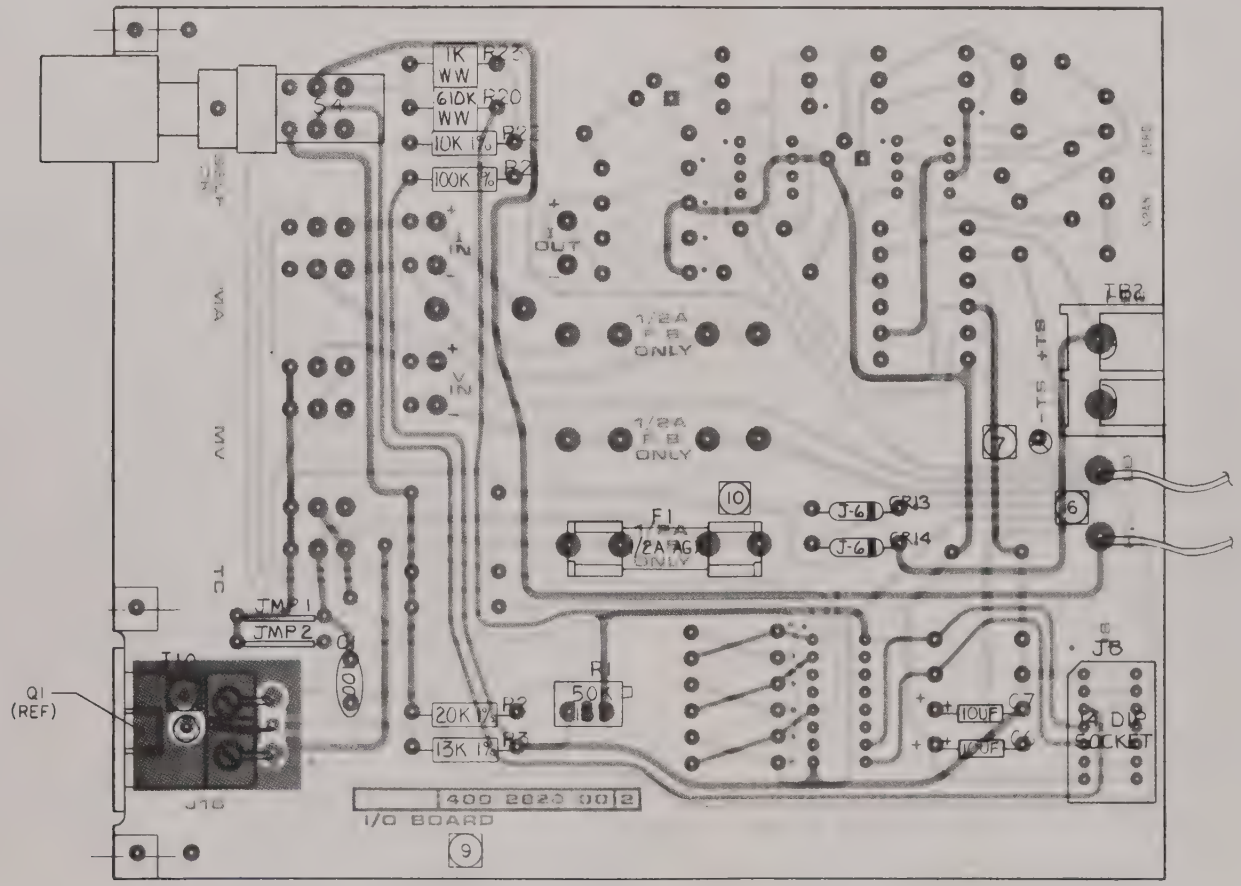


BOARD HOLE NO.	WIRE COLOR
7	VIO
8	GRY
9	WHT
10	WHT/BLK
11	WHT/BRN
12	WHT/RED
13	WHT/ORN

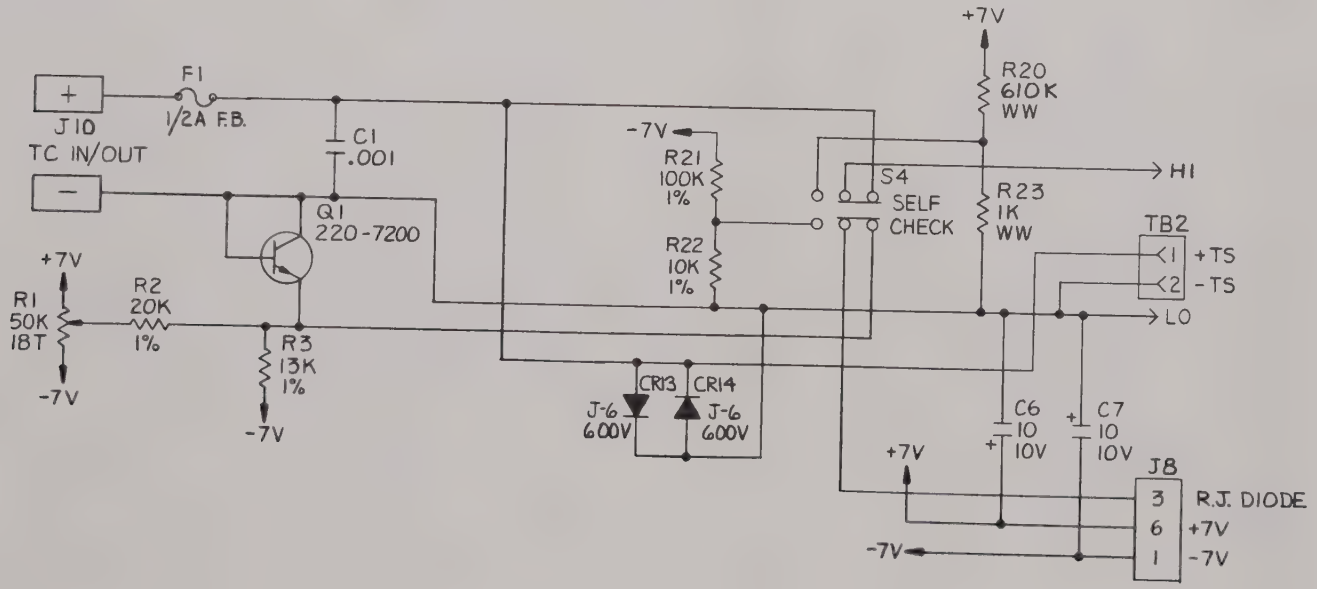
Assembly
POWER PACK/POT
407-4110-00



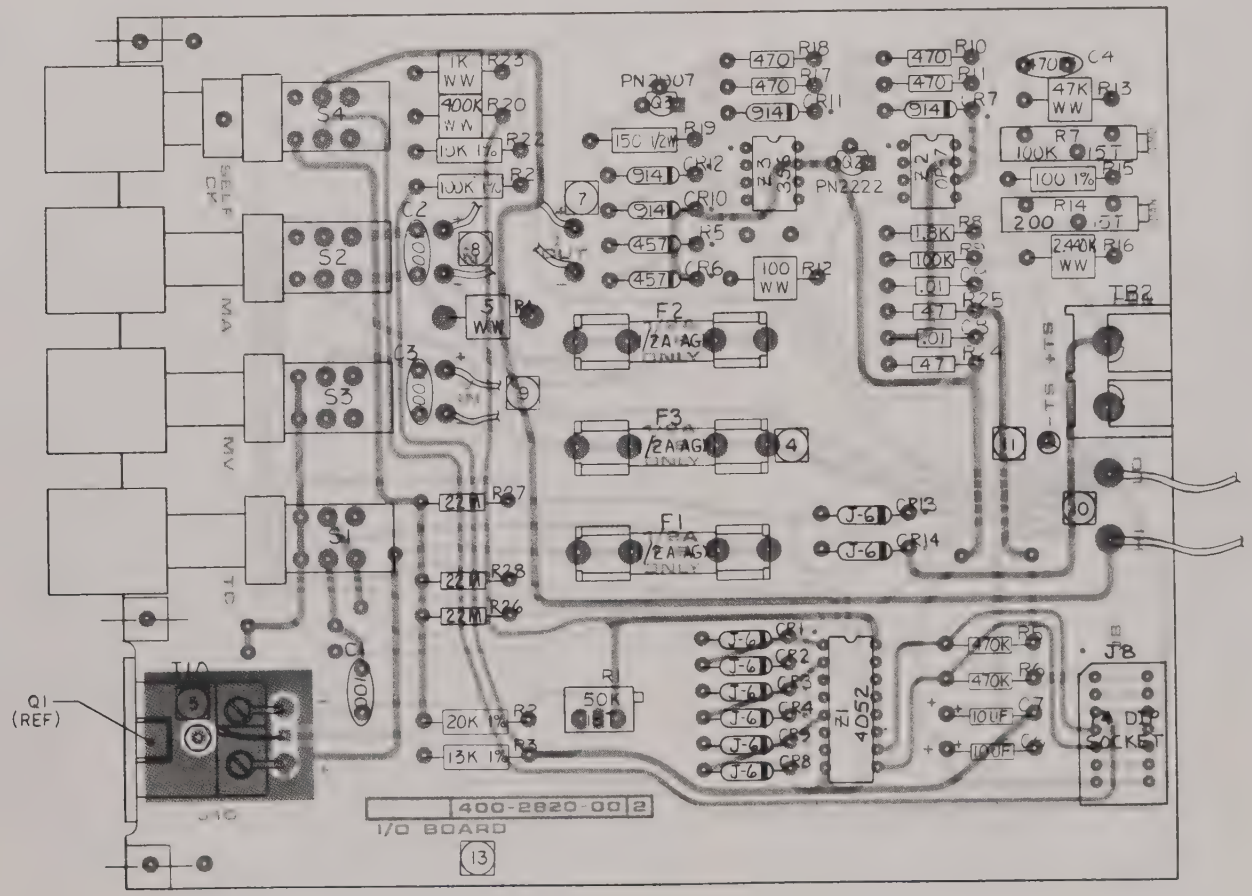
Schematic
POWER PACK/POT
407-6110-00



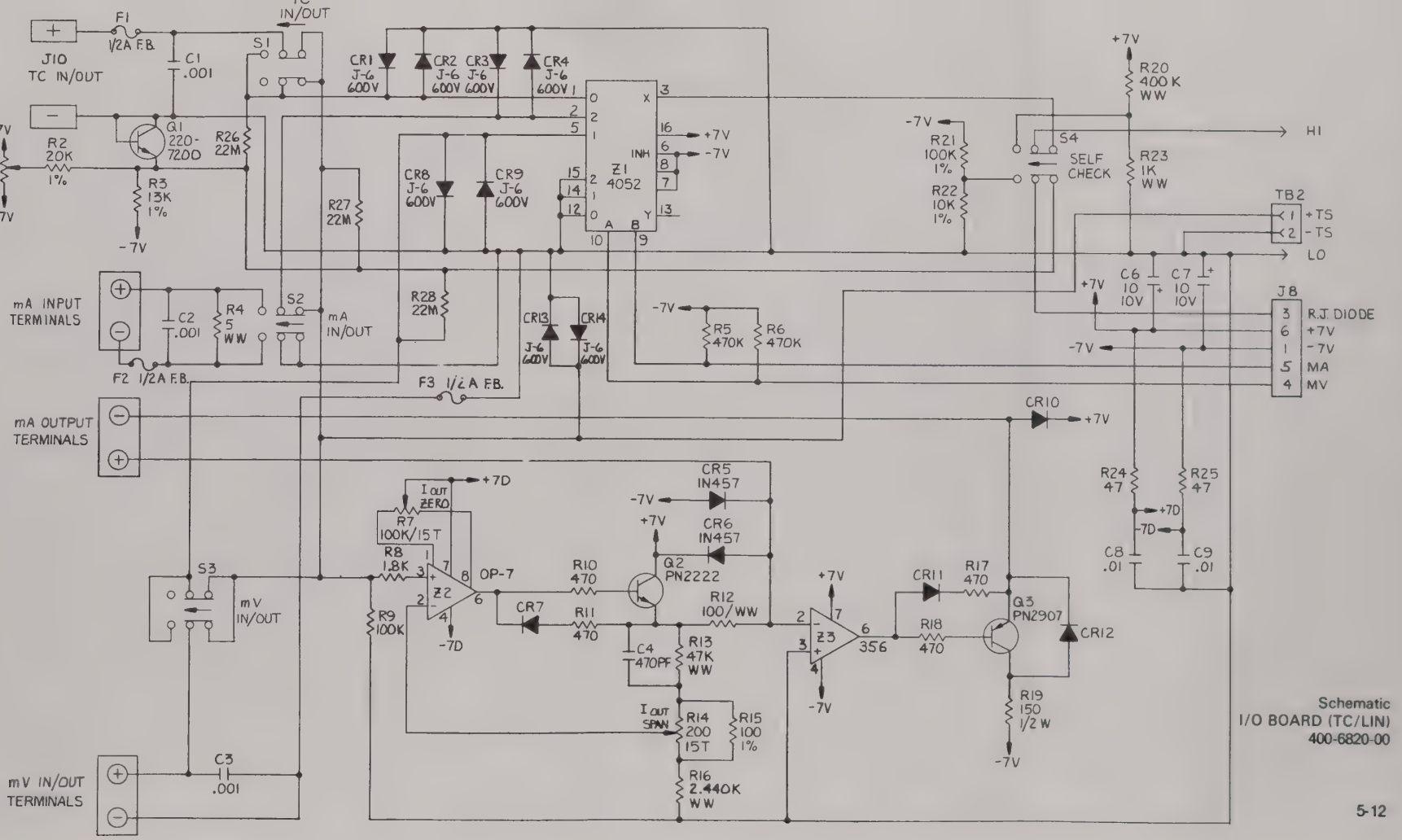
Assembly
I/O BOARD (TC)
400-4821-00



Schematic
I/O BOARD (TC)
400-6821-00



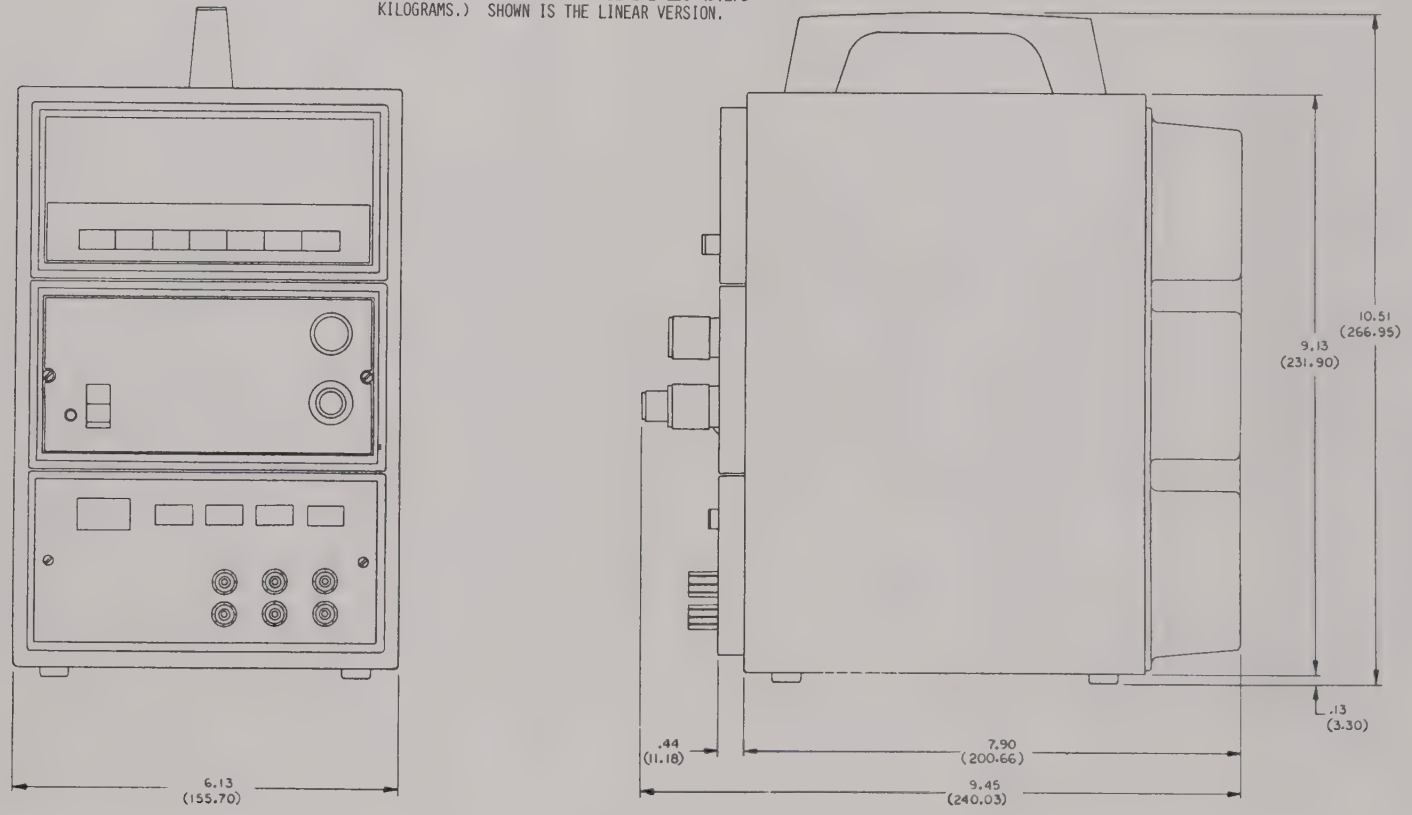
Assembly
I/O BOARD (TC/LIN)
400-4820-00



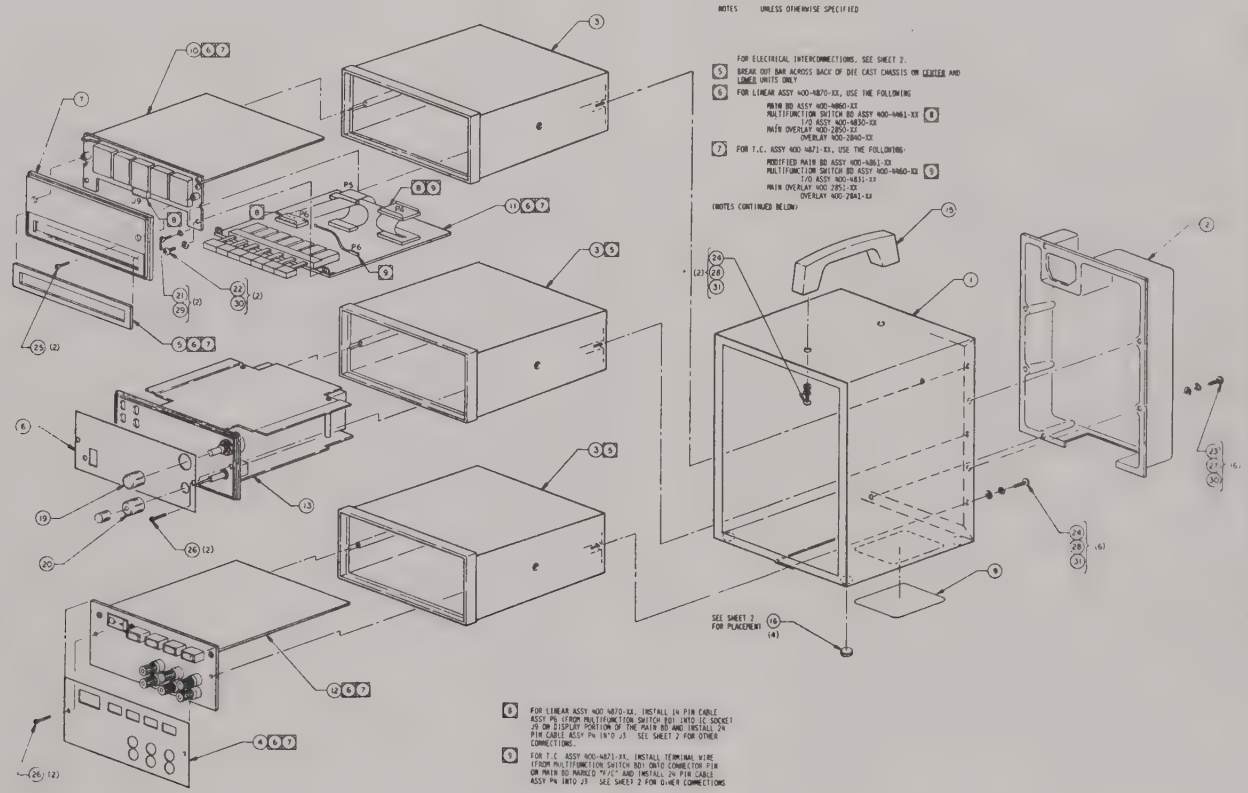
Schematic
I/O BOARD (TC/LIN)
400-6820-00

NOTES: UNLESS OTHERWISE SPECIFIED

1. DIMENSIONS ARE IN INCHES AND (MILLIMETERS).
2. NET WEIGHT OF THIS UNIT IS 11-1/2 LBS (5.175 KILOGRAMS.) SHOWN IS THE LINEAR VERSION.



OUTLINE DRAWING
400-8090-00


NOTES UNLESS OTHERWISE SPECIFIED
5 FOR ELECTRICAL INTERCONNECTIONS, SEE SHEET 2.
BREAK OUT BAR ACROSS BACK OF DIE CAST CHASSIS ON CENTER AND LOWER UNITS ONLY
6 FOR LINEAR ASSY 400-4870-XX, USE THE FOLLOWING
MAIN BD ASSY 400-4860-XX
MULTIFUNCTION SWITCH BD ASSY 400-4461-XX 8
I/O ASSY 400-4830-XX
MAIN OVERLAY 400-2850-XX
OVERLAY 400-2840-XX
7 FOR T.C. ASSY 400 4871-XX, USE THE FOLLOWING
MODIFIED MAIN BD ASSY 400-4861-XX
MULTIFUNCTION SWITCH BD ASSY 400-4460-XX 9
I/O ASSY 400-4831-XX
MAIN OVERLAY 400 2851-XX
OVERLAY 400-2841-XX
(NOTES CONTINUED BELOW)
SEE SHEET 2 FOR PLACEMENT
8 FOR LINEAR ASSY 400 4870-XX, INSTALL 14 PIN CABLE ASSY P6 (FROM MULTIFUNCTION SWITCH BD) INTO IC SOCKET J9 ON DISPLAY PORTION OF THE MAIN BD AND INSTALL 24 PIN CABLE ASSY P4 INTO J3 SEE SHEET 2 FOR OTHER CONNECTIONS.
9 FOR T.C ASSY 400-4871-XX, INSTALL TERMINAL WIRE (FROM MULTIFUNCTION SWITCH BD) ONTO CONNECTOR PIN ON MAIN BD MARKED "9/C" AND INSTALL 24 PIN CABLE ASSY P4 INTO J3 SEE SHEET 2 FOR OTHER CONNECTIONS

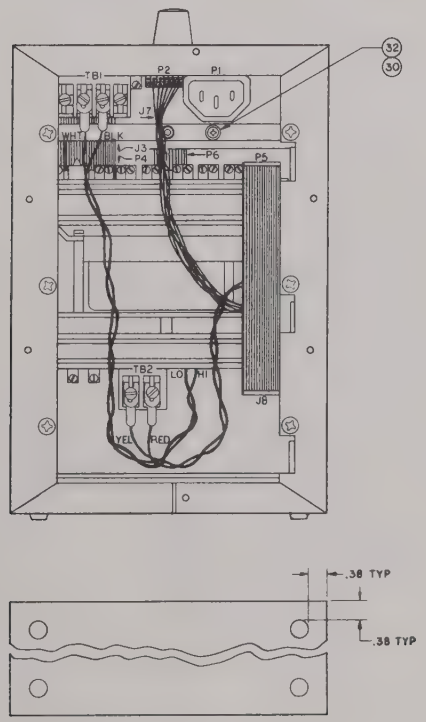
ASSEMBLY, DIGITAL CALIBRATOR 400-4870-00/400-4871-00

Item No.	Description	Part No.	Qty
1	Case, three tier	400-2011-00	1
2	Cover, rear, three tier	400-2012-00	1
3	Chassis, die-cast	400-2010-05	3
4	Overlay, Version L I/O	400-2840-00	1
5	Overlay, Version L Main	400-2850-00	1
(4)	Overlay, Version T I/O	400-2841-00	1
(5)	Overlay, Version T Main	400-2851-00	1
6	Overlay, Power Pack/Pot	407 2120-00	1
7	Front Panel	400-2760-01	1
9	Label, serial tag	400-2890-00	1
10	PCB assy, Main Bd , Version L	400-4860-00	1
(10)	PCB assy, Main Bd., Version T	400-4861 00	1
11	Assy, Multifunction, Version L	400-4461 00	1
(11)	Assy, Multifunction, Version T	400-4460-00	1
12	Assy, I/O, Version L	400-4830-00	1
(12)	Assy, I/O, Version T	400-4831 00	1
13	Assy, Power Pack/Pot	400-4900-00	1
14	Manual, Owners (not shown)	400-4880-00	1
15	Handle, molded plastic	991-050-08	1
16	Foot, Black, adhesive back	991 055-04	4
17	Power cord (not shown)	993 200-07	1
18	Shipping container (not shown)	999-000-81	1
19	Knob, black	991 050 20	1
20	Knob, concentric set, black	991 050 21	1
21	Screw, Panhd PH, 4-40 x 3/8	980-440-038	2
22	Screw, Panhd PH, 6-32 x 1/4	980-632 025	2
23	Screw, Panhd PH, 6-32 x 3/8	980-632-038	6
24	Screw, Panhd PH, 8 32 x 1/2	980 832 050	8
25	Screw, Fill hd PH, 4-40 x 3/8	982 4400-038	2
26	Screw, Fill.hd PH, 4-40 x 3/4	982-4400-075	4
27	Washer, Flat #6	986-100-06	6
28	Washer, Flat #8	986 100 08	8
29	Washer, Splitlock #4	986-200-04	2
30	Washer, Splitlock #6	986-200-06	9
31	Washer, Splitlock #8	986-200-08	8
32	Screw, Panhd PH, 6-32 x 5/8	980 632 063	1

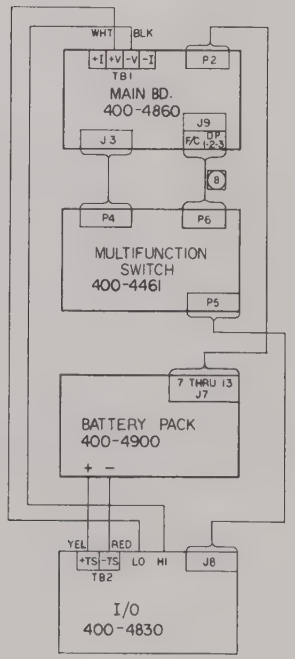
(Item nos. in parenthesis are found in Version T instru[illegible] only.)

ASSEMBLY/INTERCONNECTIONS
400-4870-00, 400-4871-00

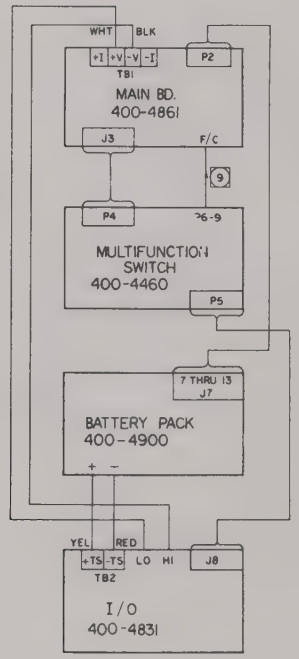
REAR VIEW
(COVER OMITTED FOR CLARITY)



LINEAR
(400-4870)
WIRING DIAGRAM



T.C.
(400-4871)
WIRING DIAGRAM



SECTION 6

PARTS LISTS

6.1 INTRODUCTION

This section contains the electronic parts list for the Model 466 calibrator, subdivided by circuit board assemblies. Each list contains a brief description of the part, the quantity per assembly, factory part number, and the manufacturer's name. (In some cases, the part is available from several manufacturers and when this occurs, only one is listed for convenience.)

The manufacturer's part number is not shown for parts which are easily obtained by using only the description. On parts requiring a special type or construction, the manufacturer's part number or part grouping is given in parentheses as part of the description.

MAIN BOARD, ASSEMBLY 400-4860-00/400-4861-00

Ref.Des.	Description	Qty	P/N	Mfgr
Z9	IC, PMOS, LSI	1	000-7500-00† 000-7502-00*	DORIC
Z1,Z3	IC, qd. anlg. sw. graded 4016	2	000-7700-00	RCA
Z2	IC, Precision op-amp, OP-07CP	1	965-607-00	PMI
Z4,Z5	IC, op-amp, LF356	2	065-616-00	Fairchild
Z6	IC, op-amp, 301A		965-592-01	NSC
Z7	IC, inv. NOR, NAND, 4572	1	965-618-00	Motorola
Z8	IC, dual op-amp, LM 358	1	965-617-00	NSC
Z10	IC, hex dsply driver, 75494	1	965-619-00	NSC
Z11	Res Network, 39 ohms	1	950-003-90	Bourns
Z12	Rectifier, bridge WL005M	1	966-002-26	GI
Q1	Transistor, MPSU55	1	964-040-55	Motorola
Q2	Transistor, MPSU05	1	964-040-05	Motorola
Q3	Transistor, selected	1	220-7200-01	Doric
Q4,Q5,Q8	Transistor, 2N4250	3	962-425-00	Fairchild
Q6,Q7	Transistor, FET 2202	2	100-722-02	Solitron
Q9 Q15	Transistor, MPSA13	7	964-040-03	Motorola
Q16	Transistor, TIS97	1	964-040-97	TI

† Version T only
* Version L only

MAIN BOARD, ASSEMBLY 400-4860-00/400-4861-00 (continued)

Ref.Des.	Description	Qty	P/N	Mfgr
CR1	Diode, 1N4577 (6.4 V)	1	961-457-70	Siemens
DS1-DS5	Display, 7-seg LED, HDSP-3405	5	968-086-00	HP
R1,R2	Res, Film, ¼W 5%, 10	2	940-001-00	Corning
R3,R9	Res, Carbon, ¼W 5%, 4.7	2	942-204-79	Mepco
R4,R8, R37	Res, Carbon, ¼W 5%, 1K	3	942-201-02	Mepco
R5,R7	Res, Carbon, ¼W 5%, 4.7K	2	942 204-72	Mepco
R6,R21	Res, Carbon, ¼W 5%, 1M	2	942 201-05	Mepco
R10,R11	Res, WW, 10K .05% (J115)	2	934-211-75	Jordan
R12	Res, Film, RN60C 3.65K	1	920-436-51	Dale
R13	Pot, Cermet, 1K (72XL)	1	960-011-25	Beckman
R14	Pot, Cermet, 100K (89P)	1	960-011-09	Beckman
R15	Res, Carbon, 2W 5%, 10K	1	942-501-03	Mepco
R16,R31	Res, Carbon, ¼W 5%, 220K	2	942 202-24	Mepco
R17	Res, Carbon, ¼W 5%, 22	1	942-202-20	Mepco
R18,R32	Res, Carbon, ¼W 5%, 2.2M	2	942 202 25	Mepco
R19,R22	Pot, Cermet, 100K (72XL)	2	960-011 18	Beckman
R20	Res, WW, 1K .05% (J115)	1	934-211-74	Jordan
R23	Res, WW, 56.25K .05%, (J115)	1	937 201-14	Jordan
R24,R34 R42,R43	Res, Carbon, ¼W 5%, 100K	4	942-201-04	Mepco
R25	Res, Film, RN60C 2.02M	1	921-420-24	Dale
R26	Res, Carbon, ¼W 5%, 22M	1	942 202-26	Mepco
R27	Res, Carbon, ¼W 5%, 10M	1	942-201-06	Mepco
R28	Pot, Cermet, 500 (72XL)	1	960 015-07	Beckman
R29	Pot, Cermet, 10K (72XL)	1	960-011-16	Beckman
R30	Res, Carbon, ¼W 5%, 22K	1	942-202-23	Mepco
R33	Res, WW, 990.75K .05% (J115)	1	937 201 13	Jordan
R35	Res, Carbon, ¼W 5%, 100	1	942-201-01	Mepco
R36	Res, Carbon, ¼W 5%, 390K	1	942 203-94	Mepco
R38	Pot, Cermet, 2K (72XL)	1	960-012-08	Beckman
R39	Res, Film, RN60C 10.4K	1	920-410-42	Dale
R40	Res, Carbon, ¼W 5%, 15M	1	942-201-56	Mepco
R41	Res, Carbon, ¼W 5%, 4.7M	1	942-204-75	Mepco
R44	Pot, Cermet, 50K (89P)	1	960-015-04	Beckman
R45	Pot, Cermet, 25K (89P)	1	960-012-53	Beckman
R46,R47	Res Carbon, ¼W 5%, 10K	2	942 201 03	Mepco
C1 C3	Cap, Disc .005 @ 1KV (5GA)	3	900 021 07	Centralab
C4 C6	Cap, Elect, 390 @ 15V (672D)	3	910 390 15	Sprague
C7,C8	Cap, Tant, 10 @ 35V (196D)	2	916-010-35	Sprague
C9,C11	Cap, Tant, 2 2 @ 35V (196D)	3	916 220 04	Sprague
C12,C13	Cap, Disc 100pF @ 1KV (5GA)	2	901 011 01	Centralab
C14	Cap, Polyc, 22 @ 100V (BA2B)	1	911-032-24	IMB
C15	Cap, Polyc, 2 @ 100V (BA2B)	1	911-032-05	IMB
C16	Cap, Mica, 3pF (DM15)	1	915-030-30	Arco
C17,C25 C26	Cap, Axial, .01 @ 50V	3	900-021-07	Varadyne
C18	Cap, Mica, 100pF (DM15)	1	915-031-01	Arco
C20,C21	Cap, Disc .02 @ 500V (5GA)	2	900-082-02	Centralab

MAIN BOARD, ASSEMBLY 400-4860-00/400-4861-00 (continued)

Ref.Des.	Description	Qty	P/N	Mfgr
C24	Cap, Mica, 220pF (DM15)	1	915-032-21	Arco
C27,C28	Cap, Disc, .1 @ 50V (Z5U)	2	900 021-02	Varadyne
T1	Transfrmr, Power (115/230 VAC)	1	400 7040-01	Actown
TB1	Terminal strip, 4T (6PCR04-002)	1	973-010-37	Reed Dev.
P2	Conn, PC7M	1	973-380-00	Berg
P1	Housing, AC receptacle	1	400-2490-01	Benda Tool
P1	Ground pin, AC receptacle	1	400-2500-01	Benda Tool
P1	Power pin, AC receptacle	1	400 2510-01	Benda Tool
	IC Socket, 40-P DIP, 340-AG38D	1	992-010-18	Augat
J3	IC Socket, 24-P DIP, 324-AG38D	1	992 010-70	Augat
J9(4860 only)	IC Socket, 14 P DIP, LO-PROF, 514-AG37D	1	992 010-71	Augat
S2(4861 only	Switch, 6 pole DIP	1	969 050-00	Grayhill
	Cable, 18-pin solid flat, FSN23A-18	1	993-100-00	Ansley

MULTIFUNCTION BOARD (TC/LINEAR), ASSEMBLY 400-4461-00

Ref.Des.	Description	Qty	P/N	Mfgr
Q1 Q3	Transistor, Darlington, MPSA13	3	964-040 03	Motorola
Q4	Transistor, 2N2222	1	962-222-20	Motorola
CR1 CR15	Diode, 1N914	15	961 091-40	Motorola
R1	Res, Film, RN60C 1.30M	1	922-413-04	Dale
R2,R10 R12,R14, R15	Pot, 15-T Cermet, 1M (89P)	6	960-011-13	Beckman
R3	Res, Film, RN60C 117K	1	920-411-73	Dale
R4 R9	Res, Film, RN60C 1M	2	920 410-04	Dale
R5	Res, Film, RN60C 100K	1	920 410 03	Dale
R6	Res Film, RN60C 20K	1	920-420-02	Dale
R7	Res, Film,RN60C 13K	1	920-413-02	Dale
R13 R36 R37	Res, Carbon, ¼W 5% 22M	3	942-202 26	Mepco
R16 R20	Res, Carbon, ¼W 5%, 27K	2	942-202 73	Mepco
R17 R18 R21-R23	Res, Carbon, ¼W 5%, 47K	5	942 204 73	Mepco
R19	Res Carbon ¼W 5% 10K	1	942-201 03	Mepco
R24	Res, WW, 20K .05% (J115)	1	934 212 03	Jordan
R25 R27 R29,R31 R33,R35	Pot 15-T Cermet, 200 (89P)	6	960-012 02	Beckman
R26	Res, WW, 25 834K .05% (J115)	1	934 202 06	Jordan
R28	Res WW, 25 696K .05% (J115)	1	934-202 05	Jordan
R30	Res WW 16 826K .05% (J115)	1	934 216 68	Jordan
R32	Res, WW, 19.637K .05% (J115)	1	934-020-07	Jordan

MULTIFUNCTION BOARD (TC/LINEAR), ASSEMBLY 400-4461-00 (continued)

Ref.Des.	Description	Qty	P/N	Mfgr
R34	Res, WW, 9.3185K .05% (J115)	1	937-201-24	Jordan
R38	Pot, 18-T Cermet, 50K (68X)	1	960-050-02	Beckman
C1	Cap, Disc, 220pF @ 1KV (5GA)	1	901-012-21	Sprague
S1	Switch, DIP SPST	1	969-050-09	SMK
S2-S7	Switch, Interlocking Assy. (6PB-4PB/IL)	1	969-010-21	Centralab
S8	Switch, push/on/off DPDT (1PB-2P/PP)	1	969-010-11	Centralab
4	Cable, 24-pin DIP	1	993-100-10	Circ. Assy.
P5,P6	Cable, 14 cond. flat, 11"	2	993-100-20	Symbex

MULTIFUNCTION BOARD (TC ONLY), ASSEMBLY 400-4460-00

Ref.Des.	Description	Qty	P/N	Mfgr
CR1-CR12	Diode, 1N914	12	961-091-40	Motorola
R1	Res, Film, RN60C 1.30M	1	922-413-04	Dale
R2	Res, Film, RN60C 117K	1	920-411-73	Dale
R3	Res, Film, RN60C 20K	1	920-420-02	Dale
R4	Res, Film, RN60C 13K	1	920-413-02	Dale
R5,R10, R26,R27	Res, Carbon, ¼W 5%, 22M	4	942-202-26	Mepco
R6-R9 R11,R12	Pot, 15 T Cermet, 1M (89P)	6	960-011-13	Beckman
R13	Res, Carbon, ¼W 5%, 10K	1	942-201-03	Mepco
R14	Res, WW, 20K .05% (J115)	1	934-212-03	Jordan
R15,R17 R19	Pot,15-T Cermet, 200 (89P)	3	960 012 02	Beckman
R16	Res, WW, 25.834K .05% (J115)	1	934 202 06	Jordan
R18	Res, WW, 25.696K .05% (J115)	1	934 202 05	Jordan
R20	Res, WW, 181.972K .05% (J115)	1	934 202 02	Jordan
R21,R23 R25	Pot, 15-T Cermet, 2K (89P)	3	960 012 06	Beckman
R22	Res, WW, 180.637K .05% (J115)	1	934 202 01	Jordan
R24	Res, WW, 187.165K .05% (J115)	1	934 202 03	Jordan
R28	Pot, 18-T Cermet, 50K (68X)	1	960 050 02	Beckman
C1	Cap, Disc, 220pF @1KV (5GA)	1	901-012-21	Sprague
S1	Switch, DIP SPST	1	969-050-09	SMK
S2-S7	Switch, Interlocking Assy. (6PB 2P/IL)	1	969-010-21	Centralab
S8	Switch, push/on/off DPDT (1PB 2P/PP)	1	969-010-11	Centralab
P4	Cable, 24-pin DIP	1	993-100-10	Circ. Assy
P5	Cable, 14 cond. flat, 11"	1	993-100-20	Symbex
P6	Assy, terminated wire 8", red	1	993 340-02	Donic

POWER PACK/POT, ASSEMBLY 407-4110-00

Ref.Des.	Description	Qty	P/N	Mfgr
Z1	IC, Quad op-amp, LM324	1	965-599-00	NSC
Z2	IC, CMOS Hex inverter, 74C04	1	965-587-05	NSC
Z3	IC, Regulator 78MGU1	1	965-644-00	Fairchild
Q1	Transistor, 2N3646	1	962-364-60	Motorola
Q2,Q6	Transistor, 2N4250	2	962-425-00	Fairchild
Q3,Q5	Transistor, 2N3393	2	962-339-30	Sprague
Q4	Transistor, MPSU55	1	964-040-55	Motorola
CR1	Rectifier, Bridge WL005	1	966-002-26	GI
CR2-CR4	Diode, 1N4002 100PIV @ 1A	3	966 002-00	Motorola
CR5-CR7	Diode, 1N5818 30PIV @ 1A	3	961-581-80	Motorola
CR8	LED, Red (Dialco 550-01-03)	1	968-010-10	Dialco
CR9	Diode, Zener 1N5236B	1	961-523-62	Motorola
R1	Res, Film, RN60C 5.11K	1	920-451-11	Dale
R2	Res, Film, RN60C 6.34K	1	920-463-41	Dale
R3	Pot, Cermet 2K (72XL)	1	960-012-08	Beckman
R4,R27	Res, Carbon, ¼W 5%, 1M	2	942-201-05	Mepco
R5,R13	Res, Carbon, ¼W 5%, 4.7M	2	942-204-75	Mepco
R6, R23	Res, Carbon, ¼W 5%, 10K	2	942-201-03	Mepco
R7	Res, Carbon, ¼W 5%, 680	1	942-206-81	Mepco
R8	Res, Film, RN60C 1K	1	920-410-01	Dale
R9	Res, Film, RN60C 2.49K	1	920-424-91	Dale
R10	Pot, WW, 10K (Amp 4201B103)	1	960-011-21	Amp
R11	Res, Film, RN60C 5.49K	1	920-454-91	Dale
R12/S2	Pot/Sw 100K 2P (A-B 23M080)	1	960-011-35	A-B
R14	Res, Film, RN60D 490	1	920-349-00	Dale
R15	Res, Film, RN60D 10	1	920-310-09	Dale
R16,R18	Res, Film, RN60C 20K	2	920 420-02	Dale
R17	Res, Film, RN60C 499	1	920-449-90	Dale
R19,R24	Res, Carbon, ¼W 5%, 100K	1	942-201-04	Mepco
R20	Pot, Cermet 100K (72XL)	1	960-011-18	Beckman
R21	Res, Carbon, ¼W 5%, 680K	1	942-206 84	Mepco
R22,R26 R28	Res, Carbon, ¼W 5%, 1K	3	942 201 02	Mepco
R25	Res, Carbon, ¼W 5%, 330	1	942-203-31	Mepco
R29	Res, Carbon, ¼W 5%, 2.7	1	942-202-79	Mepco
C1,C2	Cap, Elect, 390 @ 15V (672D)	2	910 390-15	Sprague
C3	Cap, Elect, 270 @ 40V (672D)	1	910-270-40	Sprague
C4	Cap, Axial, .01 @ 50V	1	900-021-07	Varadyne
C5-C7	Cap, Tant, 47 @ 20V (196D)	3	916 471 20	Sprague
S1	Switch, rocker (7101J-1V5B)	1	969-020-00	C&K
P4	Conn, Plug (Molex 09 18 5031)	1	973 070 10	Molex
J7	Assy, Cable I/O Power Pack	1	993-300-06	Doric

I/O BOARD (TC/LINEAR), ASSEMBLY 400-4820-00

Ref.Des.	Description	Qty	P/N	Mfgr
Z1	IC, Mux, 4052 (selected)	1	000-8051-00	National
Z2	IC, Precision op-amp, OP07CP	1	965-607-00	PMI
Z3	IC,Op-amp, LM356N	1	965-616-00	National
Q2	Transistor, 2N2222	1	962-222-20	NCS
Q3	Transistor, 2N2907	1	962-290-70	NSC
CR1-CR4, CR8,CR9, CR13,CR14	Diode, 1N4005 600PIV @ 1A	8	966-002-04	Motorola
CR5,CR6	Diode, 1N457A	2	961-045-70	Fairchild
CR7,CR10-CR12	Diode, 1N914	4	961-091-40	Motorola
R1	Pot, 18-T Cermet, 50K (68X)	1	960-050-02	Beckman
R2	Res, Film, RN60C 20K	1	920-420-02	Dale
R3	Res, Film, RN60C 13K	1	920-413-02	Dale
R4	Res, WW, 5 ohms .05% (J115)	1	937-201-16	Jordan
R5,R6	Res, Carbon, ¼W 5%, 470K	2	942-204-74	Mepco
R7	Pot, 15-T Cermet, 100K (89P)	1	960-011-09	Beckman
R8	Res, Carbon, ¼W 5%, 1.8K	1	942-201-82	Mepco
R9	Res, Carbon, ¼W 5%, 100K	1	942-201-04	Mepco
R10,R11 R17,R18	Res, Carbon, ¼W 5%, 470	1	942-204-71	Mepco
R12	Res, WW, 100 .05% (J115)	1	934-211-73	Jordan
R13	Res, WW, 47K .05% (J115)	1	934-211-60	Jordan
R14	Pot, 15-T Cermet, 200 (89P)	1	960-012-02	Beckman
R15	Res, Film, RN60D 100	1	920-310-00	Dale
R16	Res, WW, 2.44K .05% (J115)	1	934-202-08	Jordan
R19	Res, Carbon, ½W 5%, 150	1	942-301-55	Mepco
R20	Res, WW, 400K .05% (J115)	1	934-211-84	Jordan
R21	Res, Film, RN60C 100K	1	920-410-03	Dale
R22	Res, Film RN60C 10K	1	920-410-02	Dale
R23	Res, WW, 1K .05% (J115)	1	934-211-74	Jordan
R24,R25	Res, Carbon, ¼W 5%, 47	2	942 204 70	Mepco
R26,R27 R28	Res, Carbon, ¼W 5%, 22M	3	942 202 26	Mepco
C1 C3	Cap, Disc, .001 @ 1KV (5GA)	3	900 081 03	Centralab
C4	Cap, Disc, 470pF @ 1KV (5GA)	1	901 014 71	Centralab
C6,C7	Cap, Tant, 10 @ 10V (162D)	2	916-010-10	Sprague
C8,C9	Cap, Axial, .01 @ 50V	2	900-021-07	Varadyne
S1 S3	Switch, push-on off DPDT (1PB-2P/PP)	3	969 010 11	Centralab
S4	Switch, momentary DPDT (1PB-2P/M	1	969-010-03	Centralab
J8	IC Socket, 14 pin DIP with ejector	1	992 010 80	Augat
J10	Assy, Thermocouple connector	1	400-5000-00	Doric
TB2	Terminal block, 2 T	1	973-010-32	RDI
F1-F3	Fuse, ½A Fast-blo (AGX ½)	3	971-070-15	Bussman

I/O BOARD (TC ONLY), ASSEMBLY 400-4821-00

Ref.Des.	Description	Qty	P/N	Mfgr
J10	Assy, Thermocouple connector	1	400-5000-00	Doric
CR13, CR14	Diode, 1N4005 600 PIV @ 1A	2	966-002-04	Motorola
R1	Pot, 18-T Cermet, 50K (68X)	1	960-050-02	Beckman
R2	Res, Film, RN60C 20K	1	920-420-02	Dale
R3	Res, Film, RN60C 13K	1	920-413-02	Dale
R20	Res, WW, 610 .05% (J115)	1	934-202-09	Jordan
R21	Res, Film, RN60C 100K	1	920-410-03	Dale
R22	Res, Film, RN60C 10K	1	920-410-02	Dale
R23	Res, WW, 1K .05% (J115)	1	934-211-74	Jordan
C1	Cap, Disc, .001uF @ 1KV (5GA)	1	900-081-03	Sprague
C6,C7	Cap, Tant, 10 @ 10V (162D)	2	916-010-10	Sprague
S4	Switch (1PB-2P/M	1	969-010-03	Centralab
J8	IC Socket, 14-pin DIP, with ejector	1	992-010-80	Augat
F1	Fuse, ½A Fast-blo (AGX ½)	1	971-070-15	Bussman
TB2	Terminal block, 2 T	1	973-010-32	RDI

MP MASTER

MA25560